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TRANSACTIONS

OF THE

Seventh International Congress of Hygiene and Demography.

LONDON, AUGUST 10TH–17TH, 1891.

Patron:—HER MAJESTY THE QUEEN.

President:—H.R.H. THE PRINCE OF WALES, K.G.

VOLUME V.

SECTION V.

CHEMISTRY AND PHYSICS IN RELATION TO HYGIENE.

EDITED BY C. E. SHELLY, M.A., M.D.

Assisted by the HONORARY SECRETARIES of the SECTION.

LONDON:
PRINTED BY EYRE AND SPOTTISWOODE,
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SECTION V.

CHEMISTRY AND PHYSICS IN RELATION TO HYGIENE.

Tuesday, 11th August, 1891.

The President, Sir Henry Roscoe, M.P., LL.D., F.R.S., in the Chair.

Presidential Address

BY

Sir Henry Roscoe, M.P., F.R.S., LL.D., D.C.L.

The branch of the great subject of Hygiene with which we in this section have to deal, viz., that of the relation in which it stands to the sciences of chemistry and physics, is one of primary importance and interest. Indeed, taken in its most general sense, the relation of the science of health to chemistry and physics will be found to include almost all the varied subjects which come under the cognisance of this Congress, for all vital processes are regulated by chemical and physical laws, and physiology may be defined as the chemistry and physics of the animal body. Hence the preservation of a normal condition, or of health, being dependant upon these laws, it is clear that our Section is the most important of all, for it is by obeying chemical and physical laws that health is maintained, whilst by neglecting to follow them we court disease and death.

But whilst as chemists and physicists we may claim credit for laying the foundations of the edifice of Hygienic Science, we gladly admit that portions of the building have been raised by other hands, and heartily do we welcome the successful efforts which the biologist, the physician, the engineer, and the statesman have made to help us to complete the building up of a condition of things by which the amount of preventible disease is reduced to its possible minimum, and that of health and well-being increased to the maximum possible under the necessary circumstances of our lives.

As to the progress which during the last half century has been made towards the attainment of this end—he who runs may read. Those who can carry their minds back 50 years will be free to confess that at that time, whether in England or abroad, the principles of Sanitary Science were recognised only by a very few men of light and leading, and that any attempt to carry out these principles were, indeed, few and

far between. Fifty years ago our notions of the nature of contagion, of the causes which lead to the spread of epidemic diseases were of the crudest and vaguest description. We then had no idea of the fact now not only proved beyond doubt, but strongly impressed on the public mind, that both water and milk are fertile carriers of disease if contaminated even ever so slightly with infectious material.

In those days "pump" water was believed to be wholesome if only it was cool and sparkling, and water from a source now recognised as dangerously impure was preferred to the pure article which came from a distance in the city mains. Now the sanitary authority closes all doubtful wells, and municipalities incur vast expense in bringing home to every one a pure supply of this necessity of life. Still much remains yet to be done for an adequate supply—especially in rural districts where the village pump is too often the sole means of existence, and where that pump is not infrequently in close proximity to sources of dangerous impurity. Moreover, even where the supply is of good quality, its quantity often fails in dry seasons from lack of any impounding system of the flood waters. That 50 years since our knowledge of these matters was limited is due to the fact that in those days chemists were unable to decide whether a water was harmless or dangerous. The methods of analysis were then crude and insufficient; and even now, when these methods have been greatly improved, the most expert analysts may find themselves in disagreement, on a mere chemical examination, as to whether a given water is fit to drink or not. The discussion of these methods of examination on Thursday next may, I should hope, contribute to the elucidation of these doubtful points.

Fifty years since no one realised that the existence of cesspools under their houses, of which there were then thousands in London, was a source of danger to the inhabitants. The idea of getting rid of and of utilising fœcal matter was laid hold of ages ago by nations, such as the Chinese, whom we in our wisdom term barbarians, whilst the civilised European waited till the middle of the nineteenth century before he discovered that if he would preserve his life he must remove from his neighbourhood the refuse which accompanies that life, and even now, at the end of the century, he is far from having solved the question of the best way of its removal, much less that of its utilization. On Wednesday next we shall have an opportunity of learning the opinion of those competent to give it on the much vexed questions of the chemical and physical principles involved in the treatment of sewage; and if we can lay down, even in outline, what these principles are, our section will not have met in vain.

The question of air pollution, which will come on for discussion during our sittings, is a much more difficult though an equally important one. We can bring pure water into our houses by pipes, we can also take away the polluted water by sewers, we can see the fresh water running in, and we know, if our drains are in order—an assumption it is true, and perhaps a bold one—that our dirty water at least goes away from us. In the case of the air, we cannot regulate the fresh supply so easily; nature, it is true, does much for us, indeed if she did not, we should be badly off. We cannot see the air, whether pure or otherwise:

our sense of smell, may, if it be sensitive—which is again an assumption often incorrect—possibly tell us that something is wrong, though it by no means follows that an odourless air is pure and healthy; but to ascertain how far the air is impure, and to express it in figures was, so far as concerns many of the most important of these impurities, impossible 50 years ago, and is only now beginning to be understood. But even were we able to detect the presence in the air of the spores of the as yet undetected influenza microbe we should be far from having a means of freeing the air from it. By filtration through cotton wool, air can be obtained practically free from microbic life as well as from dust particles and fog, but such air filtration can only be adopted in a very limited number of cases, and is altogether useless for general purposes. One of these few instances is that of the House of Commons, where a system of air filtration has been successfully adopted, by which the air of the debating chamber has been preserved perfectly free from fog as well as from microbic life if the doors are kept closed.

The discussion on town fogs and their prevention, which is to be introduced by Dr. Russell, will enable us at any rate to form an idea of the causes and possible mode of preventing these serious drawbacks to a city life. A scientific inquiry, if it does not at once succeed in finding a cure for the evil may, at least, point the way to prevention, and I shall be surprised if we do not find that the ultimate panacea will consist in using gaseous fuel and the electric light.

Another source of air pollution, more easy to grapple with, lies in the escape of deleterious gases from chemical works and other manufactories. The removal of many causes of such pollution has been satisfactorily accomplished in this country under what are known as the Alkali Acts, or more properly the Noxious Vapours Acts. Thanks to the care with which these Acts have been worked both by the Government inspectors and the manufacturers themselves, the serious complaints which arose of nuisance due to the escape of acid and other noxious vapours are now no longer heard; and not only has the public been the gainer by the stoppage of the escapes which formerly occurred, but the manufacturers themselves have also benefited, inasmuch as they have had their attention directed to improvements in their processes which have proved remunerative.

The great smoke question is one upon which I hope some light will be thrown by the discussion which will take place during our meeting. Much, doubtless, can be done in preventing the output of smoke from factories and other places in which large quantities of coal are burnt, but, after all, the smoky atmosphere of our towns is caused chiefly by the thousands of domestic fires, and at once to alter these so as to prevent smoke, or to insist upon gaseous fuel being generally used instead of coal, is to expect the impossible.

I have said that the foundation of hygienic progress is to be sought in the application of chemical and physical principles. This is true not only of the matters of every day experience to which I have already referred, but also of the most recent and astounding discoveries, showing the dependence of the health of the community on the actions of microbic life. Thus Pasteur and his pupils have proved that these actions on the

host or body receiving the microbes as guests, are to be attributed rather to definite chemical products formed by the living micro-organisms than to the organisms themselves. For just as in the well-known instance of the vinous fermentation, the products of the action of the yeast plant on sugar are alcohol, carbonic acid, and subsidiary compounds, so each definite micro-organism—such, for example, as that peculiar to diphtheritis—engenders certain active chemical principles which are capable of effecting serious or fatal changes, characteristic of this disease, within the animal body. Hence the ultimate causes of epidemic disease rest upon a chemical basis, and as we find in a simple chemical an antidote for poisoning by any of the commoner chemical poisons, so it would appear that an antidote for hydrophobia, for example, is to be found in the complicated chemical products of the life of the micro-coccus characteristic of this disease. How these antidotes—except in the most simple cases, such as acid and alkali and the like—act is as yet unknown. We do, however, know that the growth and life functions of this yeast plant are stopped in presence of an excess of the poison, alcohol, which it secretes, and this fact may help us to explain, to some extent, the protective action exerted by the chemical poison developed by many pathogenic micro-organisms. The elucidation of this subject, all-important for the health of the community as well as of the individual, is one of the most pressing scientific needs of the day. To isolate the various chemical products, to study their actions, both chemically and pathologically, is a necessary step towards the attainment of the end which we all have in view, viz., the prevention and cure of disease. Hence, it will be admitted by all, that whilst the determination of the morphological characters of micro-organic life is an essential preliminary, it is to the examination of the life-functions of the organism, and especially to those connected with the production of its peculiar chemical poison, that we must look for the complete solution of the problem; and therefore it is in the laboratory of the chemist, and by the application of chemical and physical methods of research that progress in these matters will, in the coming time, be made. So again, I say that the foundations of hygienic progress are to be sought in the application of the principles of chemistry and physics.

And now, gentlemen, I know that all well-wishers to this progress, whether English members or the foreign guests who have honoured the Congress by their presence, will rejoice to learn that we in England, determined no longer to lag behind our continental friends, are about to establish a National Institute of Preventive Medicine, in which not only researches of the kind I have alluded to can be satisfactorily carried out, but where instruction in the numerous special branches of science, upon which the health of the nation depends, can be given. Those who have interested themselves in this movement feel that it is no less than a national disgrace, that whilst almost every other civilised nation has established an institute of the kind in its midst, we in England should stand alone inactive and supine. We believe that the necessity for such a national institute only requires to be made generally known to be universally acknowledged, and we feel confident that now having

obtained the first step towards the attainment of our object, viz., recognition under license of the Board of Trade, the Council of the Institute will only have to ask in order to obtain the considerable amount of pecuniary support necessary for carrying on the work of the institute on a scale worthy of the country. This support must come wholly from private sources; for our Government, unlike that of many countries, as yet holds aloof from supporting institutes of this kind however necessary they may be to the general well-being of the country. The time may not be far distant when different views will prevail, and when Parliament will consider it one of its first and most binding duties to support by Imperial grant an institution whose sole aim is that of increasing our knowledge of the conditions upon which the health of the nation ultimately depends, and of diffusing that knowledge widely throughout the land.

A vote of thanks was accorded to Sir Henry Roscoe on the motion of Dr. Russell, seconded by Professor Odling.

On Town Fogs and their Effects.

BY

Dr. W. J. Russell, F.R.S.

Until 1880 the formation of fog was looked upon as arising simply from the separation of liquid water, probably in the form of hollow vesicles, from an atmosphere saturated with aqueous vapour; but in that year Aitken showed that the determining cause of the separating out of liquid water, and consequent formation of fog, was dust present in the air. He pointed out that a change of state, a gas passing to a liquid or a liquid to a solid, always occurred at what he terms a "free surface"; that as long as a molecule of liquid water is surrounded by like molecules (and the same with gaseous water) we do not know at what temperature, or whether at any temperature, they would change their state; but if in contact with a solid, then—at the surface where they meet—the change will occur. If the solid be ice it may become liquid; or the liquid may become solid; and the same kind of action occurs when the liquid is in contact with its own vapour. In fact, what we call the freezing and boiling points of a body are the temperatures at which these changes take place at such free surfaces. The dust always present in the atmosphere offers this free surface to the gaseous water, and thus induces its condensation. This specific action of dust varies very considerably,—first with regard to its composition, and second with regard to the size and abundance of the particles present. Sulphur burnt in the air is a most active fog producer; so is salt. Many hygroscopic bodies form nuclei having so great an affinity for water that they can cause its condensation from an unsaturated atmosphere. At the same time non-hygroscopic bodies,

such as magnesia and many others, are powerful fog-producers; no doubt their activity may in part be attributed to their being good radiators of heat, and thus by becoming cooled, inducing condensation. Mr. Aitken also showed that the products of combustion, even when the combustion is perfect, are powerful fog producers,—a fact which has an important bearing on the production of town fogs. One other point in these experiments I cannot omit mentioning; it is the exceedingly minute amount of matter capable of inducing fog. In his first series of experiments, Mr. Aitken showed that $\frac{1}{100}$ of a grain of iron wire, however often it was heated, evolved on each heating sufficient dust to cause a visible fog; and afterwards, with still more delicate apparatus, that $\frac{1}{2000}$ of a grain of either iron or copper when treated in the same way gave a similar result; and from these last experiments he infers that even $\frac{1}{100000}$ grain of either wire, if only slightly heated, would yield sufficient nuclei to cause a visible amount of fog. It is of much importance and interest, seeing how small a quantity of dust is required for the production of fog, to know that even this small amount may be filtered out of the air by passing it through cotton wool, and that an air may thus be obtained in which a fog cannot be produced. Mr. Aitken's description of such an atmosphere is at first most alluring; for he says that if there was no dust in the air there would be no fogs, no mists, and probably no rain; but he goes on to state that when the atmosphere became burdened with supersaturated vapour, it would convert everything on the surface of the earth into a condenser, every blade of grass and every branch of a tree would drip with moisture deposited by the passing air, our dresses would become wet and dripping, and umbrellas useless; but our miseries would not end here, for the inside of our houses would become wet, the walls and every object in the room would run down with moisture. I think if we picture to ourselves this state of things we may be thankful that there is dust—and fog. Dust in its finer forms is invisible to us, but as its delicate particles become loaded with moisture, it becomes a fine mist, which is dense if the number of particles are many. But if the dust particles are fewer, the amount of aqueous vapour remaining the same, each particle will have a larger amount of condensed moisture to carry, and will give rise to a more coarse-grained fog; the moisture, or some of it, will be more feebly attached to its nuclei, producing then what is known as a wet fog; whereas at least one most important fact in the production of a dry fog is the strong affinity between the nuclei and the condensed vapour. As most of you are no doubt aware, Mr. Aitken has invented a most ingenious method for counting the number of dust particles in air, and has obtained most interesting and valuable results. I can only mention here that some of these results deal with the clearness of air in relation to the number of dust particles present; and other results show how little effect rain has in diminishing the amount of the finer dust in air. Towns obviously supply dust of all kinds, and therefore offer every inducement for fogs to form, and some at least of these dust particles will be capable of causing the condensation of moisture even from an atmosphere which is not saturated with aqueous vapour. This condensation of moisture is a very complete process for removing all kinds of impurities from the air. Floating

particles are free surfaces, and, becoming weighted by the moisture they condense, tend to sink; even the gaseous impurities in the air will be dissolved and carried down by the moisture present. Experiment confirms this, for it has been proved how correctly the impurities of an air can be ascertained by determining the composition of dew, even if this be artificially and locally formed. It is of importance to note that even the purely gaseous emanations from our towns cannot pass away when a fog exists, as is shown by the accumulation of carbonic acid which takes place during a fog. Taking four volumes in 10,000 volumes as the normal amount of carbonic acid in London air, some years ago I found that it increased in the case of a dense fog to as much as 14·1 volumes, and often to double the normal amount, which must represent a very serious accumulation of the general impurities in the air.

A fog in this way becomes a useful indicator of the relative purity of the atmosphere in which it forms. If pure aqueous vapour be condensed it gives a white mist—a country fog, a sea fog—and a white light seen through it is not converted into a red light; but in town fogs the whiteness of pure mist disappears and becomes dark, in some cases almost black, in colour, the change being produced by the foreign matters floating in the air. By far the most abundant colouring matters of our town fogs are the products generated by the imperfect combustion of coal, but in addition to these bodies, many others must obviously find their way into the air over a town; especially will there be dust from the universal grinding and pounding going on in street-traffic and many mechanical operations, from the general disintegration of substances and the decomposition of perishable materials, all of which will add something to the air, and will become an integral part of the fog. However, although it is often said that a town fog is so dense that it may be cut with a knife, still it is difficult to condense so much of it that it can be subjected to a searching chemical analysis. In 1885 by washing foggy air I was able to determine the amount of sulphates and chlorides present, and—as indicators of organic matter—the quantity of carbon and nitrogen in the fog. The results showed strikingly how largely the amounts of organic matter and of ammonia salts in the air varied with the weather. No case of dense fog occurred when the experiments were being made, but the mean of several experiments clearly showed that in foggy weather the amount of organic matter was double as much as existed in the air in merely dull weather, and that the amount of sulphates and chlorides increased under like conditions, but not to the same extent. Fog may, however, be made to give its own account of its constituents; for we have only to collect and analyse the deposit which it leaves to learn what its more stable constituents are. We have to thank the air analysis committee of the Manchester Field Naturalists' Society for the most complete analysis of such a deposit which has yet been made. The deposit analysed occurred during the last fortnight in February of this year, 1891, and was obtained from the previously washed glass roof of the plant houses at Kew, and from Messrs. Veitch's orchid houses at Chelsea. At Kew 20 square yards of roof yielded 30 grammes of deposit. At Chelsea the same area gave 40 grammes,

which represents 22 lbs. to the acre or six tons to the square mile, and the composition of these deposits is as follows :—

	Chelsea.	Kew.
Carbon	39·0	42·5
Hydro-carbons	12·3	4·8
Organic bases (pyridines, &c.)	2·0	
Sulphuric acid (SO_3)	4·3	4·0
Hydrochloric acid (HCl)	1·4	0·8
Ammonia	1·4	1·1
Metallic iron and magnetic oxide of iron	2·6	41·5
Mineral matter (chiefly silica and ferric oxide)	31·2	
Water, not determined (say difference)	5·8	5·3
	100·0	100·0

These analyses give, I believe for the first time, a definite account of the composition of fog deposits. Soot and dust rendered sticky and coherent by hydrocarbons are by far the principal constituents, but I should like to give you the striking description which Professor Thiselton Dyer has sent me of the deposit collected at Kew. He says "it was like a brown paint, it would not wash off with water and "could only be scraped off with a knife. It thickly coated all the "leaves of the evergreens, and upon what have not yet been shed it "still remains." In the above analysis it is curious to note the large amount of metallic iron and magnetic oxide of iron. The details with regard to these very interesting analyses we shall hear from a member of the Manchester Committee, and I will only ask you to note how large a proportion of these deposits arises from the imperfect combustion of coal. We also learn from the Manchester Committee some interesting facts with regard to fog deposits which occurred last winter in their city. The deposit which was collected from aucuba leaves contained as much as 6 to 9 per cent. of sulphuric acid, and 5 to 7 per cent. of hydrochloric acid, mostly of course in a state of combination, but the deposit was, they say, "actually acid to the taste." Moreover, three days' fog deposited per square mile of surface, in by no means the worst part of Manchester, 1½ cwts. of sulphuric acid, and even as far out of the city as Owens College, on the same area, over 1 cwt. of acid and 13 cwts. of blacks.

There is still one other point characteristic of town fogs to be noted; it is their persistency in an atmosphere considerably above the dew point. A country fog under such circumstances at once passes away; a town fog apparently does not do so. There seem to me to be two reasons for this; one is that the moisture is protected, and its evaporation to a large extent hindered, by the presence of oily matter; and secondly, that when the moisture has really gone, the soot and dust remain to produce a haze. The great distances to which fogs will travel is also remarkable, for they have on many occasions been traced to a distance of at least 25 to 35 miles from London, and I believe I might say to 50 miles.

I have so far discussed the production and composition of town fogs; and before considering their effects, would say a word

on the question of whether in London they are increasing in frequence and density. A complete and accurate record of fogs in London is not kept; several stations are required, and a correct method of registering the density and of distinguishing the difference between haze and fog is necessary, but fortunately there is a fair approximation to this complete registration of London fogs published by the Meteorological Office in their daily reports. The observations are made every morning at Brixton and every afternoon at Victoria Street; and, from a paper by Mr. Brodie on "Some remarkable features in the winter of 1890–91" published in the journal of the Royal Meteorological Society, I learn that the number of fogs thus registered as having occurred each winter since 1870 is as follows:—Winter being represented by the months, December, January, and February. I have divided these 20 years into four groups or five years each—

Between	1870–1875	93	fogs occurred.
„	1875–1880	119	„
„	1880–1885	131	„
„	1885–1890	156	„

It appears, then, that during the last 20 years there has been a steady increase in the number of winter fogs. I am not aware of any data to prove whether the density of these fogs has increased, but it is probable that the increase in number of fogs largely depends upon an increase of atmospheric impurity, and on the conversion of haze and mist into obvious fog; and as the great colouring matter of fog arises from the combustion of coal, I have drawn up the following table from information which has been kindly furnished to me by Mr. G. Livesey and Mr. T. B. Scott, of the Coal Exchange. It gives the amount of coal really consumed annually in London, but does not include the coal used by the different gas companies.

COAL CONSUMED IN LONDON.

(That used by Gas Companies deducted).

Year.	Tons.
1875	4,882,233
1876	4,988,280
1877	4,143,909
1878	4,973,147
1879	5,833,891
1880	5,334,823
1881	5,598,281
1882	5,343,974
1883	5,872,310
1884	5,669,281
1885	6,026,063
1886	6,096,732
1887	6,231,956
1888	6,463,498
1889	6,390,850

For the first five years the amount given in the table is rather too high, as the quantity used by the surburban gas companies could not be ascertained and deducted. The quantities apply to what is known as

the London district, an area with an average radius of 15 miles round London. The table shows an absolute increase during the last 15 years of two million tons of coal, that is, half as much again is now burnt as was burnt in 1875.

Supposing only 1 per cent. of sulphur in this last yearly amount is converted into sulphuric acid ($H_2 SO_4$) and passed into the air, it would give 195,720 tons of this acid. The five years' averages of winter fogs give a steady increase, but obviously the number in each winter will vary much with the atmospheric conditions; for instance, last winter was remarkably favourable for the development of fog; for again taking the figures of the last 20 years, the average number of days of fog during the winter is 25, but last winter the actual number was 50. A form of fog well termed "high fog" now frequently occurs in London. The lights in a street during this form of fog are often as visible as on a clear night, but above hangs a fog so dense that the darkness of night prevails during the day. This particular form of fog appears to have become much more frequent of late years; in fact it is doubtful whether in former times it ever occurred. The immediate cause of this new form of fog is difficult to explain.

The general atmospheric conditions which induce fog are a still and moist air and a high barometer—a state of the air most usual under anticyclonic conditions. The immediate determining cause, however, of a fog is usually a sudden and considerable fall of temperature. Mr. Brodie also points out that last winter was a time of calms; the percentage of such days on the average for the last 20 years is 9·7, but last winter the number was 22; emphatically, he says, it was an anticyclonic winter.

London has always been the head-quarters of town fogs, but now all the large towns appear to be imitating it in this respect. This is what we must expect, for an increase of population means an increase of combustion of coal, and that means a pouring into the atmosphere of more and more carbon, hydrocarbons and sulphuric acid; in dry and windy weather all these bodies may be scattered so as not to produce appreciable effects, but let the air be still, or even approach a state of aqueous saturation and then, as we have seen, every particle of dust and dirt becomes a centre for moisture to deposit on, and we shall have a fog imprisoning all impurities and offering them to us for inhalation. To burn coal so that only products of complete combustion may escape is a problem of much difficulty and is comparatively rarely done. Certainly the domestic fireplace does not do it, but, on the contrary, is the principal cause of the dark colour of our fogs. Many manufacturers, however, liberally contribute to produce the same effect.

I turn now from the constitution and production of fog, to note some of the effects it produces. First, with regard to health; details on this point I leave to those who are more able to describe them than I, but I have a few words to say with regard to the effect of London fogs on the death-rate in general. There are many people who feel so strongly the unpleasantness of fog that it induces them to magnify its results and make extraordinary statements with regard to the mortality it produces. It has even by some been likened in deadliness to the Great Plague of London and to other great epidemics. To ascertain how far such views

were correct I studied the Registrar-General's reports for the times of fogs, and expressed his results by the curves drawn on a series of diagrams.* I selected times of fog, viz., the winters of 1879–80, 1889–90, and 1890–91, and represented graphically the temperature, the amount of fog, and the death-rate for each day. The results are, I think, worthy of careful study. The first thing learned from these diagrams is that by far the greater number of fogs occur when there is a great fall of temperature; this is closely followed after a few days by a great increase in the death-rate; how much of this increase is to be attributed to the fog and how much to the fall in temperature may be difficult to determine. We have evidence that when fogs occur without fall of temperature, they do not appear to be followed by any remarkable increase of death-rate, for on December 15th 1889 there was a dense fog and the temperature was even above the average, and under these conditions the death-rate remained far below the average; on December 13th and 14th in the same year again there is a dense fog, and average temperature, and only an average death-rate, and the same thing happened on February 4th in 1890, when, notwithstanding a dense fog, the death-rate remained remarkably low; and last winter on November 13th and 14th there was again a dense fog, a high temperature, and an average death-rate. With these four exceptions, depression of temperature goes with fog. There is no case of depression of temperature not followed by increase of death-rate.

That many people suffer much, both physically and mentally from the effects of fog there can be no doubt; but as far as I can interpret these returns of the Registrar-General, they do not confirm the popular impression that fog is a deadly scourge; at the same time it is beyond doubt that an atmosphere charged with soot, dust, and empyreumatic products is an unwholesome atmosphere to breathe; though I think that the principal cause of the great increase of mortality when fogs occur is attributable rather to the sudden fall of temperature which usually accompanies fog than to the fog itself.

So many toxic effects are now traced to the action direct or indirect of bacteria, that it is satisfactory to learn from the experiments of Dr. Percy Frankland that fogs do not tend to concentrate and nurture them; for he found there were remarkably few bacteria in London air during a time of fog.

The deleterious action of town fogs on plants is more marked and more easy to investigate than its effects on animals. Nurserymen have long known from experience that a town fog will penetrate even their heated greenhouses, and will with certainty kill many of their plants, especially their orchids, tomatos, and in fact most tender and soft-wooded plants. But on this point I cannot do better than quote what the Director of Kew Gardens, Professor Thiselton Dyer, says in a letter to me :—" With regard to plants under glass the " effect of fog is of two kinds. i. By diminishing light. This checks

* The diagrams here referred to were exhibited at the Congress.

" transpiration. The plants are therefore in the condition of being " overwatered, and a well-known consequence of this is to make them " shed their leaves wholesale. Many valuable plants which ought to be " well furnished with foliage become perfectly bare and it is impossible " ever again to recover them into sightly specimens. ii. The toxic " influence of the fog. This is most striking. It is illustrated in the " most forcible way by the enclosed memorandum.* I attribute it in the " main to sulphurous acid though I cannot help suspecting that some " hydro-carbon may also have something to do with it. The toxic " effect varies from one plant to another, some are scarcely injured " others are practically killed." He adds, "I hope you will be able to " arouse some interest in this horrible plague. If the visitation of last " year is annually repeated it must in time make all refined horticulture " impossible in the vicinity of London." I append to this paper the very interesting and important report from Mr. W. Watson to which Professor Dyer refers. This fog action on plants is so clearly marked and so deadly that it has, I am happy to say, led the Horticultural Society, aided by a grant from the Royal Society, to undertake a scientific investigation of the matter. Plants are so much more easily dealt with than people—all the circumstances of their attack by the fog and its immediate results are so much more easily noted and traced—that the investigation has already yielded important results, and we shall, I hope, hear from Professor Oliver, who is devoting himself specially to the investigation, some account of his latest results. A marked and admitted difference between town and country fogs is, that while a country fog is harmless in a greenhouse, a town fog will produce most destructive results.

There is still another action of town fogs and one which I believe is of the greatest importance. I mean its power of absorbing light. This power of abstracting light depends principally on the amount of coal products which the fog contains. The slower vibrating red rays can struggle through a fog which is absolutely impervious to the more refrangible ones. Even a mist but slightly tinged with smoke is opaque to the blue rays and this screens us from their action; but, as Aitken has lately shown, the heat rays can pass through readily. This opacity of town fog to light is, I believe, one of its most serious and detrimental characters; animals can no more thrive in semi-darkness than can plants, and important as the red rays may be, still it is undoubtedly the blue rays which are most active in producing the principal chemical changes going on around us. Experiments lately made have strongly impressed me with the wonderful activity which light confers on a mixture of air and moisture. Oxidations which in dulness and darkness are impossible, are easily and rapidly effected by aid of a gleam of sunshine, or even by a bright diffused light. It is not possible, I believe, for people to remain healthy where this source of chemical activity is cut off or even seriously diminished. In addition to the loss of physical energy, mental depression is induced by the absence of light; the whole tone of the system becomes

* *Vide* Appendix to this paper.

lowered and may fall a prey to actions which under brighter conditions it would have been able to resist.

There is another action of light which is potent for good. I mean its destructive action on many forms of bacteria. Professor Koch at the last meeting of this Congress pointed out how his tubercle bacilli are killed by even a short exposure to sunlight, and it is now well established how inimical light is to the growth and development of most kinds of bacteria. I wish I could show you in some perspicuous way the enormous power which town fog has of absorbing light, and bring forcibly before you the great difference which exists between the amount of light which reaches the inhabitants and buildings of a town as compared with the amount on an equal area free from smoke. A simple actinometer is much required, and I hope the want will soon be supplied; but at present the only records bearing on this point are the observations of direct sunshine made at various stations by the Meteorological Society and the Meteorological Office with the Campbell-Stokes instrument, and some interesting observations by Mr. H. Raffles on the distance at which objects were visible during a London winter. First with regard to the sunshine experiments. One station is situated in the heart of the city, in Bunhill Row, and it is of much interest to compare the amount of sunshine there with, first the amount in the immediate neighbourhood of London, where we are not beyond the effect of town fogs, viz., at Greenwich on one side and at Kew on the other, and also with a place not far from London which is beyond the influence of its smoke, viz., Aspley Guise, near Woburn. I have also noted the results obtained at Eastbourne, which is about as far distant from London as Aspley Guise, but in the opposite direction, and is one of the sunniest places in England.

HOURS of SUNSHINE during the year 1890.

Month.	Bunhill Row.	Greenwich.	Kew.	Aspley Guise.	Eastbourne.
January	29·9	44·0	56·0	57·3	56·9
February	42·4	62·8	57·8	70·5	106·5
March	71·3	90·8	109·3	110·4	133·5
April	127·4	141·5	144·8	137·3	170·1
May	215·7	223·9	223·9	214·3	267·9
June	128·0	125·2	141·4	119·1	165·3
July	134·1	120·6	139·9	141·3	185·6
August	164·0	153·1	182·5	189·5	200·2
September	131·6	153·2	169·5	166·1	207·4
October	89·6	96·9	121·6	135·6	125·3
November	23·4	40·8	57·6	64·7	66·9
December	0·1	2·4	0·3	13·4	38·0
Total	1157·5	1255·2	1404·6	1419·5	1723·6

Taking the totals of last year, the table shows that the hours of sunshine registered at Bunhill Row was 1158, at Greenwich 1255, at Kew 1405, at Aspley Guise 1420, and at Eastbourne 1724. But for our present purpose we must compare the amounts of sunshine at these

places during the winter months, November, December, January, and February, and we find that at Bunhill Row there were 95·5, Greenwich 150, Kew 171·7, Aspley Guise, 205·9 and at Eastbourne 268·3 hours of sunshine; that is, if Aspley Guise be taken as giving the normal proportion, Bunhill Row received only half its due amount, and at Eastbourne there was nearly three times as much sunshine as in the city. Now, on comparing the two other periods of four months which are comparatively free from fogs, the amount of sunshine is far more nearly equal at all stations.

——	Bunhill Row.	Greenwich.	Kew.	Aspley Guise.	Eastbourne.
March till June -	542·4	581·4	619·4	581·1	736·8
July till October -	519·3	523·8	613·5	632·5	718·5

Mr. Raffles, during the winter of 1887–88, which it should be noted was remarkably free from fogs, made a series of observations of the distances to which he could see from Primrose Hill, and found that looking south on the 152 consecutive days from November to March, only on 78 days could he see a quarter of a mile, and only on 83 days could he see to the same distance in a south-westerly direction. This conveys a good idea of the opacity of our London atmosphere.

We attempt to compensate for the darkness which fogs cause by the use of artificial light, and I have again to thank my friend Mr. Livesey for the information he has given me with regard to the extra quantity of gas burnt in London during a day of fog. He tells me that if a dense fog covered the whole of London and lasted all day, the additional amount of gas consumed would be 30 million cubic feet; but since so extensive a fog as this probably never exists and certainly never lasts all day, the actual amount consumed may be correctly reckoned at 25 million cubic feet; and, if the cost of this be calculated at 2*s*. 6*d*. per 1,000 cubic feet, which is rather below than above the actual cost, it amounts to 3,125*l*. But after all it is not the single days of dense fog that measure the extra amount and cost of artificial light used on account of fog; it is rather the continually occurring dull days and local transitory fogs which demand an extra supply of gas; and this is often 5 to 15 million cubic feet in a day, and gives a total by the end of the winter which is very considerable. As a standard of comparison I should state that the total consumption of gas in the London district in a day of 24 hours during the depth of winter is 140 million cubic feet.

Such then is an imperfect outline of the chief features and effects of town fogs; and now, what is to be said with regard to the possibility of getting rid of such fogs? This question, it seems to me, resolves itself into this; fogs cannot be prevented from forming over towns; there are, and probably ever will be, special inducements in the way of dust particles and products of combustion for fogs to form; but whether they must always be dark in colour and loaded with soot and

tarry matter is another question. The answer involves not only chemical but also social considerations. With regard to the first, my answer is, that as long as coal is burnt you will have dense fogs; grates, kitcheners, furnaces may be, and probably will be, much improved and fires may be stoked in a better way, but that the improvements will be so great that all imperfect combustion will cease I think is improbable. If this be so, there is only one other alternative, as long as coal is our source of heat, and it is to alter our form of fuel, to adopt gas and coke; the soot and tarry matters will be then done away with. The question of sulphuric acid in the air would remain, but our fogs would at least be white. There is still the social part of the question, which is not without serious difficulty, namely,—How to induce or to compel people to give up the use of coal? At the present day it would not be possible to do as it is recorded was done in the reign of Edward I.—try, condemn, and execute a man for burning coal in the city of London.

APPENDIX.

The Effects of Fog on Plants grown in the Houses at Kew. By W. Watson.

The heavy fogs experienced in the last two or three winters injured many plants in the houses at Kew. When thick fog occurred almost daily, the injury it did to many plants amounted practically to destruction. The leaves fell off, the growing point withered, and in some cases such as Begonias and Acanthads, the stems also were affected. Flowers as a rule fell off as they opened or whilst in bud. Almost all flowers which expanded were less in size than when there was no fog. The flower-buds of *Phalænopsis*, *Angræcum*, some Begonias, Camellias, &c., changed colour and fell off as if they had been dipped in hot water.

In the Palm House bushels of healthy-looking leaves which had fallen from the plants were gathered almost every morning. Plants which appeared to be perfectly healthy, when shaken would drop almost every leaf. Herbaceous plants suffered most; *e.g.*, Begonias, Poinsettias, Bourvardias, Acanthads, &c. Some herbaceous plants, however, did not suffer at all, nor were their flowers injured, as, for instance Cyclamen, Primula, Hyacinth, &c. Many hard-wooded plants lost their leaves and were otherwise damaged, viz., Boronias, some Heaths, Grevilleas, Acacias, &c. *Protea cynaroides*, a Cape plant with large laurel-like leaves, was much injured in the Temperate House (min. temp. 40°), the leaves turning black as though scalded. The same species, however, in another house where the atmosphere is drier and the temperature a few degrees higher, was scarcely affected by fog.

As a rule, the plants that were in active growth suffered most. Monocotyledonous plants and ferns for the most part were not appreciably affected by the fogs; the injury they suffered, especially last winter, being clearly due to low temperature. The effect of fog on flowers at Kew is remarkable. Generally white flowers are destroyed,

but there are some notable exceptions, viz., *Masdavallia tovarensis*, *Odontoglossum crispum*, and some *Angræcums* amongst orchids, and linums, white cyclamen, white hyacinths, white chrysanthemums, &c.

The green leaves of *Poinsettia pulcherrima* all fell off, whilst the red ones (bracts) remained, as also did the flowers. All Calanthes of whatever colour lost their flowers. The buds of the white-flowered *Angræcum sesquepedale* turned black as if boiled, whilst those of *A. eburneum*, also white flowered, were not injured and developed properly. These two plants are grown in the same house, under identical conditions, and they come into bloom about the same time.

The conditions most conducive to rest from growth, viz., a low temperature and a moderately dry atmosphere, together with diminished light—unavoidable in foggy weather—were proved at Kew to be the safest for all plants during the prevalence of heavy fogs.

The Air of Large Towns: Methods of Analysis.

PRESENTED BY

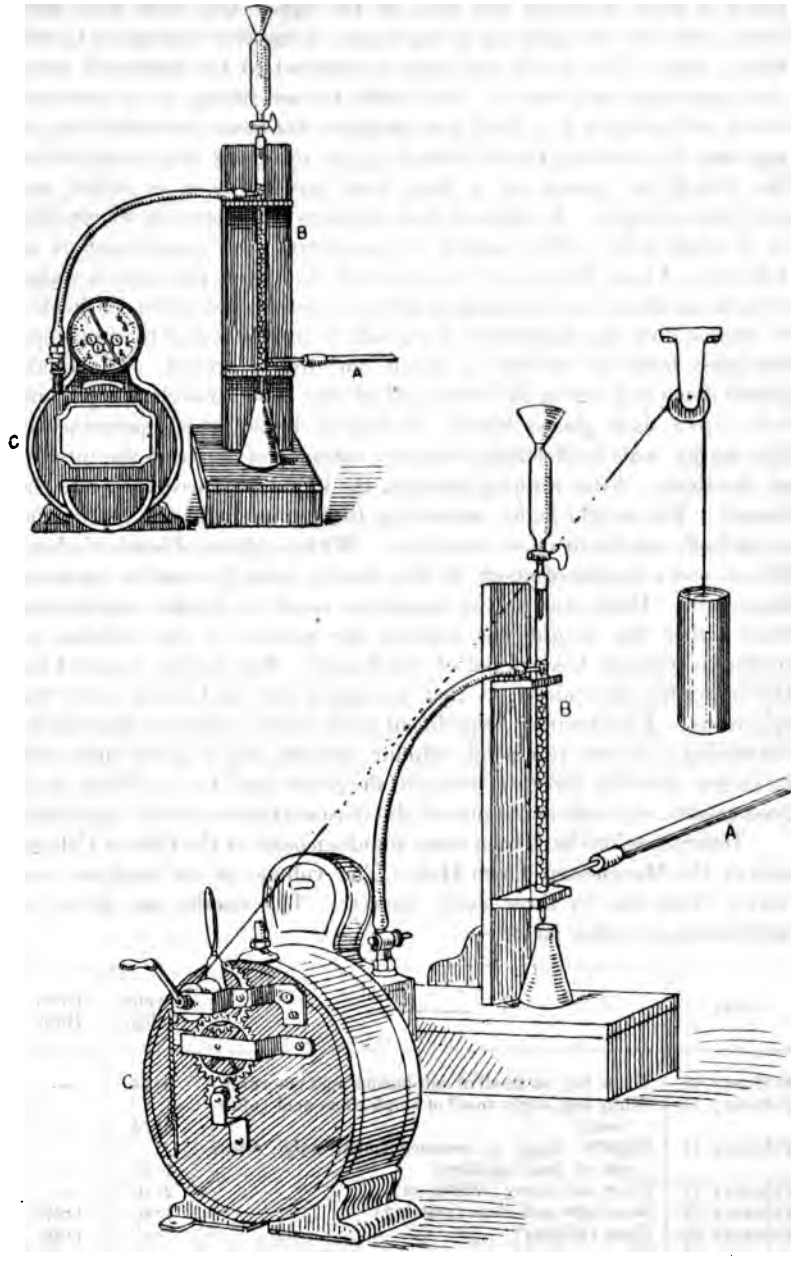
Mr. Hartog on behalf of the Air-analysis Committee of the Manchester Field Naturalists' Society, (Dr. Bailey, Dr. J. B. Cohen, Mr. Philip Hartog, and Dr. Tatham.)

A general and systematic investigation is being made of the composition of the air of Manchester in the different parts of the city. Special attention is being paid to the following points: (*a*) The differences of composition in the air of thinly and of densely populated areas; (*b*) the relation between atmospheric impurity and prevalent sickness and mortality; (*c*) the extent to which smoke and noxious vapours are due to factories and to dwelling-houses respectively; (*d*) the character of the air during the prevalence of fog; (*e*) the relative amount of light in different districts.

The following paper contains a brief account of the preliminary results which have been obtained.

It was decided first of all to deal with the presence of sulphurous acid in the air, for the following reasons:—1. Sulphurous acid, and the sulphuric acid to which it gives rise by oxidation, are distinctly harmful, even in small quantities, both to animals and the higher plants. It seems probable that the effects of town fog are largely due to the excess of sulphurous acid which it contains. 2. We know definitely that the sulphurous acid of the air arises wholly and solely from the combustion of coal, which contains from 1 to 2 per cent. of sulphur. It is a pollution especially characteristic of our great cities, and is, in our opinion, a pollution which properly directed efforts may abolish. 3. The subject is one which has scarcely been touched by previous observers, owing to the difficulties of estimating sulphurous acid when it is largely

diluted with other gases, as in the atmosphere. We describe here a simple and accurate method which we have devised for its estimation.



The apparatus used consists of three parts—A, a long glass tube about half an inch in diameter, open at both ends, which is fixed horizontally so as to project into the open air; B, a glass tower about 30 ins. high and 1¼ ins. in diameter, open at the top, and drawn out

into a fine jet at the bottom. Two side tubes are fixed to the tower, one near the bottom and the other on the opposite side near the top. The tower is filled to within one inch of the upper side tube with glass beads, and into the open top a tap-funnel is inserted through a tightly fitting cork. The lower side tube is attached to the horizontal tube; the upper one by means of wide india-rubber tubing, to a combined meter and aspirator C. This is an ordinary wet-meter converted into an aspirator by attaching toothed wheels to the revolving drum and driving the wheels by means of a wire cord passing over a pulley and carrying a weight. A series of dials registers the volume in hundredths of a cubic foot. The method of conducting the experiment is as follows:—About 250 c.c. of a solution of hydrogen peroxide in water, containing about one milligram of active oxygen in each cubic centimetre, is poured into the tap-funnel, from which it is allowed to drop onto the glass beads at the rate of about one drop a second. The liquid passes down and out at the lower end of the tube through the jet, and falls into a flask placed below. A drop of liquid which permanently fills the jet seals it effectually from the entrance of air from the interior of the room. After running through, the liquid is poured back into the funnel. The weight being wound up, the volume indicated on the dial is read off, and the drum set in motion. With a column of beads of about 20 ins. and a weight of about 10 lbs., twenty cubic feet can be aspirated in an hour. Once started, the apparatus needs no further supervision until either the weight has reached the ground or the solution of hydrogen peroxide has run out of the funnel. The period required for this is readily determined, so that no time is lost in looking after the apparatus. A preliminary experiment made with an artificial atmosphere containing a known volume of sulphur dioxide, and a check tube with hydrogen peroxide inserted between the tower and the aspirator gave good results, and sufficiently proved the trustworthiness of the apparatus.

Determinations have been made simultaneously at the Owens College and at the Manchester Town Hall. The volume of air analysed has varied from one to three cubic metres. The results are given in milligrams per cubic metre:—

1891.	———	Owens College.	Town Hall.
February 18	White fog, no smell of sulphurous acid (morning)	3·14	—
February 18	White fog, slight smell of sulphurous acid (afternoon)	3·72	—
February 19	Slightly foggy at commencement only; clear rest of time (midday)	1·95	—
February 19	Clear and sunny (afternoon)	2·10	—
February 19	Moonlight and clear (evening)	1·80	1·87
February 20	Clear (midday)	—	1·38
February 21	Clear (midday)	2·07	—
February 24	White fog and clear at close (midday)	3·08	4·06
February 25	Clear and sunny (10 to 5)	0·77	—
February 27	Foggy (9.30 to 12)	—	7·40
March 6	Very clear, wind (9.30 to 2.30)	0·28	—
March 12	Misty, bright sun (11.45 to 1.25)	0·97	—

The results show considerable variation in the amount of sulphur dioxide present in the atmosphere: The lowest result was obtained on March 6th, after two days' strong wind. The highest results were obtained on February 18th, 24th, and 27th, and on all these days there was a considerable amount of fog. The determinations made simultaneously at the Owens College and at the Town Hall show an excess of sulphur dioxide in the centre of the town.

Analyses of snow on successive days showed that during a three days' fog rather more than 1½ cwt. of sulphuric acid per square mile was deposited in the centre of the town; at an outlying station 1 cwt. of sulphuric acid and 13 cwt. of blacks per square mile was carried down during the same time.

The solid deposits on leaves of shrubs have also been analysed, and the results amply explain the difficulty experienced in growing plants and trees in towns. A series of observations on the clearness of the air, and on daylight intensity is also being made.

The organic matter in the air is to be estimated by a modification of the method used by Tidy in water-analysis. The committee adopts Dr. Russell's plan of collecting the dust, &c. by sucking a known quantity of air through glass wool, but instead of subjecting this wool to a combustion in oxygen, it is treated by dilute permanganate of potash, which is titrated back first immediately and then again after the lapse of a few hours.

An analysis was made of a deposit which was formed on plant-houses in London and supplied to the committee by the kindness of W. T. Thiselton Dyer, Esq., F.R.S., Director of Kew Gardens, and of Professor F. W. Oliver, of University College. It was found to contain :—

Carbon	39·00	per cent.
Hydrocarbons	12·30	„
Organic bases	2·00	„
Sulphuric acid	4·33	„
Hydrochloric acid	1·43	„
Ammonia	1·37	„
Metallic iron and magnetic oxide	2·63	„
Other mineral matter, chiefly silica and ferric oxide	31·24	„
Water (not determined)	—	

The committee is working in concert with a committee of the Royal Horticultural Society in London; and during the coming winter, with the aid of a grant from the Royal Society, experiments in Manchester and in the Metropolis will be carried on simultaneously.

DISCUSSION.

Dr. C. Theodore Williams pointed out the difficulty of determining how far the injurious effects observed in times of fog were due to the fog itself, or to the cold usually accompanying it. London fog was often fatal to people in a precarious state of health or suffering from advanced disease. With the majority it was not so, although it gave rise to various complaints that were not necessarily fatal. Fog induced thirst, smarting of the eyes, headache, coryza, bronchial catarrh, pharyngitis, bronchitis, and occassionally pneumonia. A prolonged period of fog also caused pallor and anæmia in a certain number of persons. He had noted that during the quarter ending March 31st, 1891, which had been a very foggy one, the Registrar-General's returns showed the mortality under one year of life to be 2·1 per cent. above the average of 20 years, and that of people over 60 to be 9·5 per cent. above the average; but the mortality of the population between one and 60 years of age to be 2·6 per cent. below the average, and this in spite of great cold and fog. He had observed cases of asthma in which the patient was benefited by a London fog, and even by the atmosphere of the Underground Railway.

Mr. Ernest Hart said that he was sure that Dr. Williams did not mean to imply that his experience of a few subjects of a disease so capricious as asthma had any general value. To create or tolerate London fogs for the sake of a few asthmatics, would be to burn down the house for the sake of roasting the pig. The mortality of London during the previous great fogs had been as great as in a cholera season. He enumerated a number of examples of the methods by which smoke might be diminished in private houses; the latter were the main sources of smoke in towns, and they affected not only the purity of air, but the amount of light, so that all London, Manchester, Sheffield, Wolverhampton, and other large towns were now, during a large part of the year, gigantic cellar dwellings. Mr. Hart mentioned the legislation suggested by the Smoke Abatement Society and approved by many local authorities, as well as by a Committee of the House of Lords.

Dr. Tripe (Hackney) agreed with Mr. Hart. In Hackney, as soon as the fogs set in, mortality increased, the effect of the fogs being to kill off those who were susceptible. Many asthmatics received quite as much benefit from breathing hydrocarbons as from a London fog.

Dr. Edward Haughton thought that there was urgent need of legislation in relation to smoke abatement, and considered that a small house tax should be imposed upon those who neglected to use grates of a proper construction. He regarded as sufficient the change recommended 90 years ago by Count Rumford, viz., the substitution as far as possible of closed grates for open ones, as the latter waste six-sevenths of the heat that is generated, besides loading the atmosphere with sulphurous acid and unconsumed carbon. The public must take the matter into their own hands and demand that their representatives should work for this reform.

Professor F. W. Oliver (Kew Gardens) drew attention to the nature and extent of the injuries caused by fog to vegetation, and gave an account of some experiments on this subject carried out under the

auspices of the Scientific Committee of the Royal Horticultural Society. He alluded in some detail to the action of sulphurous acid on vegetable protoplasm. In conclusion he referred to the work of the Manchester committee, and expressed the conviction that similar systematic records should be kept of the varying constitution of the London atmosphere.

Mr. Pridgen Teale, speaking of domestic smoke as the result of imperfect combustion, said that this could be in a great measure reduced by adopting in our fireplaces principles of construction now well understood, but violated in a large proportion of the grates produced by makers. Coal must be burned in as hot a grate as possible, viz., fire-brick, and the air should be admitted on the surface of the coal not through it, coal being burned in so large a mass as is consistent with the size of the room to be warmed.

Professor K. B. Lehmann (Würzburg), sagte:—Wir haben weniger Russ in unserer Stadtluft, aber unter schwefliger Säure leiden auch wir in Deutschland. Ich erlaube mir an die interessanten Untersuchungen zu erinnern, welche Sendtner auf Veranlassung von Pettenkofer unternommen hat. Dieselben ergaben ausser der Bestätigung einer Reihe der heute gehörten hochinteressanten Thatsachen, dass namentlich auch Statuen aus Marmor und Bronce stark unter schwefliger Säure leiden und dass letztere keine Patina ansetzen, sondern nur schwarz und rauh werden. Diese Thatsache ist für Kunststädte nicht ohne Bedeutung, wenn natürlich von weit geringerer als die hygienische. Letztere wurde von Ogata und L. Pfeiffer im Laboratorium von Pettenkofer sorgfältig durch Thierversuche studiert.

Mr. B. H. Thwaite (Liverpool) said that several years' experience had satisfied him that the cause of the black and noxious fogs of large towns was the presence in the atmosphere of the volatile hydrocarbons and the sulphurous acid resulting from the imperfect combustion of bituminous fuel. The presence of these constituents, by interference with the solar heat and light, produced the lowering of temperature and the reduction of chemical effect of the solar rays in regard to organic life. He suggested for the metropolis the conveying of gas under high pressure from the coal districts in steel tubes; the London County Council to supply such gas to the inhabitants at a reasonable price, and thus to initiate successful municipal procedure in the provinces.

Mr. Hargreaves Raffles advocated the collection and comparison of statistics relating to town fogs from all large cities.

The following *Resolution* was moved by the President, and seconded by Mr. Ernest Hart:—

> "That the Section of Chemistry and Physics in relation to Hygiene requests the President of the Local Government Board and the Home Secretary to take into consideration whether legislative measures cannot be adopted to lessen the amount of smoke produced from dwelling houses, and thus to diminish the intensity and mitigate the evil effects of town fogs."

This resolution was carried unanimously.

The Means at our disposal for Preventing the Emission of Smoke from Factories and from Dwelling Houses.

BY

ALFRED E. FLETCHER, F.I.C., &c., H.M.'s Chief Inspector under the Alkali, &c. Works Regulation Act.

The complaints that have been raised against the black smoke arising from the combustion of coal are not of yesterday. Nearly six centuries ago there was a cry in London that such a nuisance was not to be endured, and a royal edict was issued by King Edward II. in the year 1316 that coal-burning should cease, and that if any self-willed citizen should continue the obnoxious practice, and still contaminate the air with that foul vapour, his house should be pulled down about his ears.

This peremptory order for a time sufficed to stop the objectionable practice of burning smoky coal, but how long its effect lasted it is difficult to determine. It would appear that the increasing scarcity of wood, and the excellency of coal as a fuel, forced the latter again into use in spite of king and commons, for, in later times, we find Parliament petitioning the King to issue an edict to stop the burning of coal, which had again come into use. Smoke, however, seems to have held its own in spite of all attempts at repression, although fresh efforts were continually made in that direction.

In the year 1829 a select committee of the House of Commons was appointed to inquire into the effect of the smoke from factory chimneys on the public health; and, in 1843, another committee was appointed to consider the "means and expediency of preventing the nuisance of smoke." No definite result is recorded.

Ten years later a determined step was taken by Lord Palmerston, then Prime Minister. He introduced a Bill making it penal to allow black smoke to issue from any factory chimney within the metropolis or from any steam vessel plying on the Thames above London Bridge. The fines imposed were heavy and cumulative. The Act is that of 1853 (16 & 17 Vict. c. 128).

In 1856 this was followed by an amending Act extending the prohibition of smoke to all steam vessels plying below London Bridge as far as the Nore, and including bakehouses and certain factories which had been kept out of the former Act.

A marked benefit was at once felt from the operation of these Acts. Steamboats on the Thames had been accustomed to vomit out huge volumes of smoke wholly out of proportion to their size, and factory chimneys in the eastern districts of London had filled the air with blackness. Now all was changed; these chimneys seemed to keep perpetual holiday, though, indeed, the fires beneath them were never brighter, while Old Father Thames passed on his way under clearer air,

and the gardens at the Temple and elsewhere on his banks rejoiced in flowers and shrubs hitherto impossible in the smoke-laden atmosphere.

The air of London was relieved of nearly all the smoke of factory chimneys by the operation of these Acts; but the smoke from dwelling-houses remained. In the foggy weather of winter the great evils arising from this latter source are so painfully brought to the knowledge of every Londoner that he is unconscious of the relief he has gained by the operation of Lord Palmerston's Factory Smoke Acts.

The administration of the Acts is placed in the hands of the Metropolitan Police, under the control of the Home Office. In this, London is distinguished from other parts of the country. Generally, the administration of the smoke clauses of the Health Act of 1875 are in the hands of the magistrates or other local sanitary authority; and, as these are often the principal offenders, it is not surprising that excuses are found for allowing the law to remain in abeyance.

The black smoke which rises from a coal fire consists of the volatile matter which is given off under the influence of heat and yet has escaped combustion. When combustion is complete no visible smoke is discharged; the escaping gas consists then only of carbonic acid and vapour of water or steam, together with some sulphurous acid resulting from the burning of the sulphur pyrites in the coal.

Visible smoke is the result of an imperfect combustion. The gaseous matter set free when coal is heated consists of various compounds of hydrogen and carbon; when these are burned with a quantity of air insufficient to inflame the whole, the hydrogen only is burnt, while the carbon remains in the form of the black matter or soot with which we are too familiar. This black residue is made apparent also when the combustion is rendered incomplete by deficiency of heat, even if there is a sufficiency of air or oxygen—as may be shown by introducing a piece of stout copper wire into the flame of a clear-burning wax candle. The cold wire diminishes the temperature of the flame, and, rendering the combustion incomplete, causes the formation of soot, part of which is deposited on the cold wire and part rises in smoke from the top of the flame. Or, again, combustion may be rendered incomplete if sufficient time be not allowed for the due mixing of the combustible gas with the air. There must be intimate mixture, so as to promote contact between the air and every particle of the gas to be burned.

There are, then, three conditions to be observed in order to effect the complete combustion of the gaseous mixture given off from strongly heated coal:—First, there must be sufficient air; second, the air must be mixed with the gas; third, this mixture must be raised to the temperature of ignition.

It may be necessary to dwell briefly on this last head, and to observe that the temperature of ignition varies with different substances. The temperature at which sulphur will ignite is much below that at which carbon will burn. Pure hydrogen also will ignite at a lower temperature than is necessary for hydrocarbons. These and the other gases which form the mixture given off on heating a bituminous coal require a heat approaching that of whiteness to ignite them.

Now if these three conditions for the combustion of coal gas be all observed the burning will be effected, but if the observance of any one of them be omitted complete ignition will not take place.

It may be said that in most furnace fires the first condition is fulfilled, except at the time when fresh fuel is put on. When a bituminous coal is thrown onto a hot fire a large volume of gas is suddenly generated; this fills for a time the draught passages, so that just when an increased supply of air is needed less air than usual finds access to the fire.

A very common cause of failure arises from a non-observance of the second condition necessary to complete combustion. The air, though admitted both above and below the fire, never mixes with the gases thrown off from it, but passes with them in parallel streams till they reach a place where the temperature is so low that ignition is no longer possible.

In the furnaces of steam boilers a very common cause of failure in combustion is the non-observance of the third condition. The gases rising from the fire, and mixed perhaps with the air needed for burning them, are in many cases hurried from the immediate neighbourhood of the fire, where alone a sufficiently high temperature is found, to the boiler flues, where, deprived of their heat, all combustion is impossible. This is especially the case in a so-called haystack boiler, often used on river steamboats, and very commonly on the Clyde. There the fuel gases rising from the fire are at once led through cold tubes surrounded by water. In such a case combustion, if commenced, is stopped and rendered impossible from want of heat, and the unburnt gases laden with soot pass on to the chimney.

Of the fuel used in manufacturing operations about two-thirds is employed for raising steam. It is necessary, therefore, in considering the problem of smoke prevention to direct special attention to the construction of the furnaces of steam boilers. The three conditions already shown to be necessary to complete combustion must be observed, and, beyond these, it is necessary to avoid as far as possible the admission of an excess of air if the maximum duty of the fuel is to be realised.

When a furnace is fed by hand the operations of stoking must necessarily be intermittent, and consequently the due proportion between the fuel and the air cannot be constantly maintained. The necessity also of opening the fire-door is a constant source of loss, in that an excess of cold air is drawn in which tends to cool the boiler. There is evidently then a danger, on the one hand, of supplying too little air and so causing the formation of black smoke, or on the other hand of supplying too much and so causing a loss of heat.

In order to ascertain the general composition of fuel gases passing as smoke up factory chimneys I made a series of experiments in 1888, analysing the gases from furnaces in Newcastle and in Lancashire, where different kinds of coal were used. The annexed table shows the results of the analyses. It will be seen that in all cases but one there was a very large excess of air, even when black smoke was emitted. The

Analyses of Chimney Gases.

Number.	Name of Firm.	Description of Furnace.	Remarks.	Smoky.						Slight Smoke.						Clear.					
				N	O	CO_2	CO	CH_4	H	N	O	CO_2	CO	CH_4	H	N	O	CO_2	CO	CH_4	H
			Hand Fired Furnaces.																		
1	Brunner, Mond & Co.	Lancashire boiler	Before and after stoking	80·65	8·6	10·25	0·5	0	0	—	—	—	—	—	—	80·0	9·75	10·25	0	0	0
2	Copley & Co., Middlesbro'	Marine boiler	S. Durham coal. Eldon nuts.	82·78	1·72	15·0	0·5	0	0	—	—	—		—	—	79·92	15·68	4·4	0	0	0
3	Dorman, Long, & Co. do.	Lancashire boiler	Large Trindon coal	79·75	18·75	1·5	0	0	0	—	—	—		—	—	80·25	18·50	1·25	0	0	
4	„ „	„ „	„ „	—	—	—	—	—		—	—	—		—	—	80·0	19·70	0·3	0	0	0
5	„ „	„ „	„ „	—	—	—	—	—		—	—	—		—	—	83·55	8·65	7·8	0	0	0
6	Eureka Salt Co., Northwich.	Lancashire boiler	Steam jet used when stoking.	—	—	—	—	—		—	—	—	—	—	—	79·85	14·65	5·5	0	0	0
7	Eureka Salt Co., Northwich.	„ „	Steam jet used when stoking.	—	—	—	—	—		—	—	—		—	—	80·55	9·45	10·0	0	0	0
8	Eureka Salt Co., Northwich.	„ „	After stoking without steam jet.	—	—	—	—	—		80·75	10·45	8·8	0	0	0	—	—	—	—		
9	Eureka Salt Co., Northwich.	„ „	After stoking without steam jet.	—	—	—	—	—		81·5	9·45	9·05		0		—	—	—	—		
10	Musgrave Atlas Mills, Bolton.	Lancashire boiler	18 tons of coal a week of 60 hours.	—	—	—	—	—		81·8	8·65	9·55	0	0	0	80·75	12·7	6·55	0	0	0
11	Musgrave Atlas Mills, Bolton.	„ „	18 tons of coal a week of 60 hours.	—	—	—	—	—		81·25	10·70	8·05	0			—	—	—	—	—	
12	N.E. Steel Co., Middlesbro'	Lancashire boiler	Durham coal	82·95	3·5	13·25	0·05	0·25	0	—	—	—	—			80·75	8·4	10·85	0	0	0
13	Tharsis Copper Co., Newcastle.	Lancashire boiler	Small coal. Before and after stoking.	80·5	14·3	5·2	0	0	0	—	—	—	—			80·15	15·20	4·65	0	0	0
14	Newcastle Chemical Co., Salt Works.	Fire under salt pan	Small coal	—	—	—	—	—		—	—					79·55	18·45	2·0	0	0	0
15	Newcastle Chemical Co., Salt Works.	„ „	„	—	—	—	—	—		—	—					79·75	18·40	1·85	0	0	0

Analyses of Chimney Gases—*continued.*

Number.	Name of Firm.	Description of Furnace.	Remarks.	Smoky.						Slight Smoke.						Clear.					
				N	O	CO_2	CO	CH_4	H	N	O	CO_2	CO	CH_4	H	N	O	CO_2	CO	CH_4	H
16	Friar's Goose Chemical Co.	Sulphate roaster furnace.	Small coal. Before and after firing.	82·42	2·15	14·85	0·25	0	0·33	—	—	—	—	—	—	82·75	2·4	14·85	0	0	0
17	Kurtz & Co., St. Helens	Fire under caustic pot.	Before and after firing	81·80	7·50	10·25	0·45	0	0	81·15	8·75	9·5	0·5	0·1	0	—	—	—	—	—	—
18	N.E. Steel Co., Middlesbro'	Heating furnace	Durham coal	—	—	—	—	—	—	—	—	—	—	—	—	83·55	8·65	7·8	—	0	0
19	Newcastle Chemical Co.	Fire under caustic pot.	Small coal. After firing	81·95	4·45	10·35	2·35	0·75	0·15	—	—	—	—	—	—	—	—	—	—	—	—
20	Thos. Rayner, Northwich	Fire under salt pan	Four fires to pan	80·3	12·75	6·75	0·2	0	0	80·25	13·55	6·2	0	0	0	—	—	—	—	—	—
21	Sadler & Co., Middlesbro'	Fire under caustic pot.	Small coal. Before and after firing.	80·82	1·3	10·95	3·0	0·70	3·23	—	—	—	—	—	—	84·0	8·25	7·75	0	0	0
22	Tharsis Copper Co., Newcastle.	Calcining furnace	Small coal. Before and after firing.	80·25	10·0	9·0	0·75	0	0	80·75	10·25	9·0	0	0	0	80·75	12·90	6·35	0	0	0
23	A. J. Thompson, Northwich.	Fire under salt pan	Small coal. Before and after firing.	80·2	16·3	3·5	0	0	0	—	—	—	—	—	—	80·0	17·0	3·0	0	0	0
24	Bass & Co., Burton	Lownd's hollow bridges.	Before and after firing	—	—	—	—	—	—	80·9	8·35	9·85	0	0	0	80·35	12·8	6·85	0	0	0
25	Dacca Twist Mills, Manchester.	Holden's hollow bars	Before and after firing	—	—	—	—	—	—	80·85	8·9	10·25	0	0	0	79·7	15·55	4·75	0	0	0
26	Dacca Twist Mills, Manchester.	„ „	„ „	—	—	—	—	—	—	82·25	5·05	12·7	0	0	0	—	—	—	—	—	—
27	Eureka Salt Co., Northwich.	Higgins' patent blast draught.	Before and after firing	80·35 80·25	14·90 16·40	4·75 3·35	0 0	0 0	0 0	— —	— —	— —	— —	— —	— —	80·05 79·95	16·7 16·55	3·25 3·5	0 0	0 0	0 0
28	J. C. Gamble & Son, St. Helens.	Sliding door to fire, open when stoking, and closing gradually (3 mins. to shut).	Before and after firing	—	—	—	—	—	—	81·3	9·55	9·15	0	0	0	81·0	11·75	7·25	0	0	0
29	J. Schofield, Littleborough	Finch's furnace	Ordinary condition. Large coal.	—	—	—	—	—	—	—	—	—	—	—	—	80·8	13·9	5·3	0	0	0

Analyses of Chimney Gases—*continued.*

Number.	Name of Firm.	Description of Furnace.	Remarks.	Smoky.						Slight Smoke.						Clear.					
				N	O	CO_2	CO	CH_4	H	N	O	CO_2	CO	CH_4	H	N	O	CO_2	CO	CH_4	H
30	J. Schofield, Littleborough	Finch's furnace -	Ordinary condition. Large coal.	—	—	—	—	—	—	—	—	—	—	—	—	80·75	13·5	5·75	0	0	0
31	J. & E. Stott, Flixton -	Harlow's hollow bars.	After stoking - -	—	—	—	—	—	—	81·0	10·75	8·25	0	0	0	—	—	—	—	—	—
32	„ „ -	Harlow's hollow bars.	Before stoking - -	—	—	—	—	—	—	79·5	15·25	5·25	0	0	0	—	—	—	—	—	—
33	Sutton Lodge Chemical Co., St. Helens.	Fire under caustic pot.	Slanting fire bars. Do. -	79·93	11·1	7·05	1·35	0·45	0·12	—	—	—	—	—	—	80·75	13·65	5·6	0	0	0
34	Sutton Lodge Chemical Co., St. Helens.	Fire under caustic pot.	„ „ -	—	—	—	—	—	—	—	—	—	—	—	—	80·3	15·05	4·65	0	0	0
35	Talbot Mills, Manchester	Split bridge, 3 boilers.	Before and after stoking -	—	—	—	—	—	—	80·25	14·6	5·15	0	0	0	79·75	16·0	4·25	0	0	0
36	Wardle & Brown, Bolton	Split bridge, inlet of air controlled by door.	18 tons coal a week. No smoke usually.	79·6	7·00	8·75	3·25	0·40	1·00	81·25	8·4	10·35	0	0	0	80·85	11·4	7·75	0	0	0
			Mechanical Stokers.																		
37	John Bayley & Son, Bolton.	Vicars stoker - -	3½ tons coal in 10 hours -	—	—	—	—	—	—	—	—	—	—	—	—	80·75	12·0	7·25	0	0	0
38	Canon Bros., Bolton -	Jukes stoker -	22 tons a week of 60 hours	—	—	—	—	—	—	80·1	14·65	5·25	0	0	0	—	—	—	—	—	—
39	Crook & Son, Bolton -	Sinclair stoker -		—	—	—	—	—	—	80·75	11·0	8·25	0	0	0	—	—	—	—	—	—
40	Crosses and Winkworth, Bolton.	Bennis stoker - -	20 tons coal a week - -	—	—	—	—	—	—	80·25	13·9	5·85	0	0	0	80·35	14·4	5·25	0	0	0
41	Farnworth Bridge, Bolton	Cass stoker - -	Fire in ordinary condition	—	—	—	—	—	—	—	—	—	—	—	—	80·25	13·50	6·25	0	0	0
42	„ „	„ „ - -	- - - -	—	—	—	—	—	—	—	—	—	—	—	—	81·10	7·35	11·65	0	0	0
43	„ „	„ „ - -	- - - -	—	—	—	—	—	—	—	—	—	—	—	—	80·70	12·15	7·15	0	0	0

Analyses of Chimney Gases—*continued.*

Number.	Name of Firm.	Description of Furnace.	Remarks.	Smoky.						Slight Smoke.						Clear.					
				N	O	CO_2	CO	CH_4	H	N	O	CO_2	CO	CH_4	H	N	O	CO_2	CO	CH_4	H
44	Gossage & Co., Widnes	Bennis stoker	Fire in ordinary condition	—	—	—	—	—	—	—	—	—	—	—	—	80·75	11·1	8·15	0	0	0
45	„ „	Vicars stoker	„ Temp. of flue gases 380° F	—	—	—	—	—	—	—	—	—	—	—	—	80·45	12·95	6·6	0	0	0
46	Musgrave, Bolton	Vicars stoker	18 tons coal a week of 60 hours.	—	—	—	—	—	—	—	—	—	—	—	—	79·7	19·3	1·0	0	0	0
47	„ „	Hodgkinson's sprinklers.	Ordinary condition	—	—	—	—	—	—	—	—	—	—	—	—	80·35	16·4	3·25	0	0	0
48	Peter Spence & Son, Manchester.	McDougal stoker	„ „	—	—	—	—	—	—	—	—	—	—	—	—	80·35	12·45	7·2	0	0	0
49	Brunner, Mond, & Co., Northwich.	Lancashire boiler	Fired by producer gas	—	—	—	—	—	—	—	—	—	—	—	—	82·00	0·45	17·30	0	0·25	0
50	Outram, Greetland	„ „	Fired by Thwaites' producer gas.	—	—	—	—	—	—	—	—	—	—	—	—	80·60	11·15	8·25	0	0	0
51	„ „	„ „	„ „ „	—	—	—	—	—	—	—	—	—	—	—	—	80·00	13·00	7·00	0	0	0
52	„ „	„ „	„ „ „	—	—	—	—	—	—	—	—	—	—	—	—	79·80	13·70	6·50	0	0	0

exception was where gaseous fuel was used; here the balance was very nearly maintained, neither ogygen nor combustible gases being in excess.

In order to avoid the evils inherent to hand-stoking, to render the supply of coal more constant, and to keep the fire in a more uniform condition, many mechanical appliances have been adopted. In some of these the coal is continually thrown or sprinkled on to the fire in small quantities, in others it is pushed in at the front and worked back by movement of the bars till the clinkers are discharged under the bridge. A great many patents have been taken out for the various modifications of these machines, and for methods of conducting the combustion of coal in furnaces economically without the production of smoke. Some of these appliances are expensive to erect, and some have proved very expensive in use, the cost of maintenance being excessive, while some, on the other hand, effect a saving of labour and of fuel. In order, therefore, to ascertain the relative merits of all the various appliances offered with a view to economise fuel, and to prevent the discharge of smoke, a co-operative manufacturers' association* has been formed for testing practically all the principal smoke-preventing appliances found in general use, reporting on their first cost, the cost for repairs, and the comsumption of fuel in proportion both to the work done and to the amount of boiler space provided. When this report is published it will afford a valuable guide to all those manufacturers who desire to prevent the discharge of black smoke from their chimneys and to obtain the utmost efficiency from their boilers and from the fuel they consume.

One method now largely employed for effecting the complete combustion of fuel, and for preventing the discharge of black smoke, is that of converting the coal into gas and employing it in the furnace in place of solid fuel. This is done by burning the coal in a gas-producer. A limited portion of air only is admitted, so that the fue is carried off as a gas consisting of a mixture of carbon monoxide and hydrocarbons. If steam is admitted, it is decomposed by the incandescent carbon. In this operation of gas production about one-third the heat of the fuel is lost at the producer, and unless some corresponding advantage sufficient to compensate for this expenditure can be gained, the process is not economical. In many cases, convenience of application and the opportunity of saving in regenerators some of the heat justify the initial loss; in great measure it may also be recouped by so treating the gas as to separate the tar and ammonia formed in its generation. Where this is done, or where in any other way the employment of gas can be made economical, its use as a fuel is greatly to be desired as a means of preventing the emission of black smoke. Its use is particularly to be recommended in furnace fires, where a reducing atmosphere is needed, as in iron-heating furnaces. In such cases the gas may be made largely to consist of carbon monoxide and hydrogen; these, being kept in

* The Secretary of the Association is Mr. Fred. Scott, 44, John Dalton Street, Manchester.

excess of the air supplied for combustion, will afford a reducing atmosphere in the furnace, and will burn as it escapes either through the door or the chimney with a smokeless flame.

It may be confidently asserted that by the observance of the principles here laid down, and by the adoption of appliances now in frequent use, the economical use of bituminous coal as a fuel may be conducted without the discharge of black smoke.

House Smoke.—Thus far attention has been drawn to the prevention of black smoke from manufacturing operations. In many of our densely-peopled cities, however, the house chimneys contribute more to the pollution of the air than do those of factory furnaces.

Many attempts have been made by introducing close stoves or modifications of our fire-grates to prevent the emission of smoke, but our preference for the open fire, in which a flaming coal is burnt, is so determined that it would seem that smoke is inevitable. Sir Douglas Galton has done good service by devising a form of open grate in which a supply of air is so introduced as to assist greatly in the combustion of the smoke that would otherwise have escaped. Still there *is* smoke, and that, coming as it does from a thousand chimneys, forms a mighty cloud and an enormous pollution of the atmosphere. One further suggestion may, however, perhaps be made, for at any rate largely diminishing this discharge of smoke while still retaining the open fire.

Let a hot-air stove, burning coke or anthracite, be placed in the basement of the house, and a copious supply of warm, but not overheated, air be thrown into the passages and rooms. This has the effect of adding so much to the general comfort of the house that the demand on the separate fires is greatly diminished, less coal is burnt in them, and less smoke is therefore given off. The air, before coming to the stove to be warmed, should be led through a large filter-sheet of cotton wool or other fibrous matter, to collect the dust and smut. It is then not likely to convey the burnt or charred smell which arises from the scorching of the small pieces of fibre and organic matter generally to be found floating in it. As every chimney from the open fires is carrying up a large quantity of air, this air must be supplied to the house through some channel. Usually this is done by the leakages at window or door, causing unpleasant draughts; or at night, when all is close shut, this supply of air enters down the unused chimneys, bringing the damp and cold air from outside into the bedrooms, and with it a strong and most unwholesome smell of soot. All these evils are avoided by the admission of a copious stream of warmed filtered air into the house through a channel properly provided for it.

The use of gas as a smokeless fuel is largely to be recommended as a means of diminishing the production of smoke; its employment for cooking, heating of water for baths, &c. cannot be too warmly advocated, and also its largely-extended use for heating our rooms, while the general warmth of the house is maintained by a central hot-air stove.

A supply of cheap gas, and its liberal use as fuel in dwelling-houses, together with the adoption of coke-fed hot-air stoves in the

basement of houses, will, I think, be found the most effectual cure for the great plague of town smoke. Where this system is adopted, the present open fires, to which we are so much attached, may remain, but their use will be greatly diminished, while our comfort both in and out of our houses will be largely increased. Seeing that by this system the carrying of coals about the house, the removal of ashes, and the daily cleaning of fire-grates would be much lessened, the use of gas as a fuel can be recommended for its economy as well as for its cleanliness.

DISCUSSION.

The Mayor of Manchester **(Alderman John Mark)** said that there was now very much less smoke in Manchester than was the case some years ago. Many efforts had been made to improve matters, but improvement had been effected mainly in manufactories. The Manchester authorities had offered special facilities to the inhabitants to burn gas for heating purposes.

Mr. Courtney (Chelsea) stated that he had in use a hand-fired furnace in which, by careful attention to the relative quantities of air and coal employed, no smoke was produced; and invited members of the section to inspect it.

Demonstration of the possibility of removing the Smoke of Fires from the Air of Towns and of using it for Disinfecting Sewers.

BY

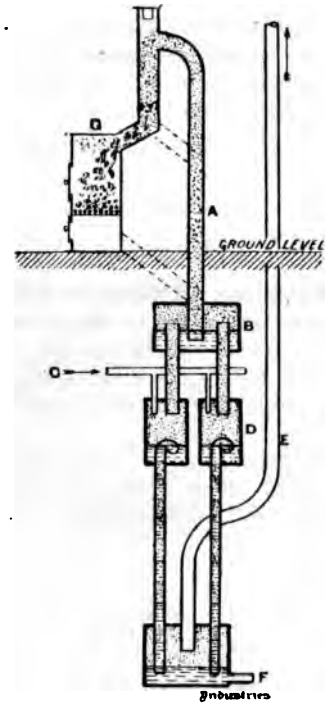
Dr. Sheridan Delépine and Mr. Alfred B. Gomess.

By means of a small quantity of water falling from a moderate height (a few feet) it is possible to produce a displacement of a large amount of air and to divert the smoke of a fire from a chimney into a system of pipes running in any direction.

By a very simple combination of channels and chambers the most fluid parts of the sewage may be used for the purpose of displacing the smoke and causing it to mix with the sewage (wherever a proper fall can be obtained by taking advantage of a natural disposition of the ground, or by raising the sewage artificially). Any supply of water could also be used for the same purpose.

A working model was shown by means of which the smoke of a fire could be carried by, and mixed with, water to any distance from and to any level below that of the fire.

The following is a brief description of the apparatus as shown in model form in the accompanying illustration.



SECTIONAL VIEW OF MODEL.

A stove G, in which turpentine is burnt, serves as the source of smoke, the stove chimney being capped so that no smoke can escape in the ordinary way. From the stove a descending flue A, communicating with the chimney and ending in a valve B, leads to the sewer. The object of the valve is to prevent any regurgitation of sewer gases when the apparatus is not at work. A number of jet pumps or exhausters D are connected with the flue or valve in such a way that a large amount of air can be displaced under low pressure by a small amount of water. The water pumps used have been specially devised for this purpose by Dr. Sheridan Delépine, and are based on the mode of action of intermittent siphons. The construction of the pump is such that a fall of only a few inches of water is sufficient to ensure a rapid removal of the smoke-laden atmosphere, and the authors point out that the same water can be used again and again provided the difference in level between one set of pumps and the other is at least 4 ft. or 5 ft. Owing to the difference of level existing between the various parts of a system of sewers, it would be possible to use filtered sewage as a source of power, and thus introduce at the same time into the sewage some of the numerous disinfectant products contained in the smoke. In this

way decomposition of the sewage would be retarded, and its value as a manure would be increased.

[NOTE.—The apparatus exhibited and represented diagrammatically above was only an experimental one, the object being to show the principle of the method as schematically as possible. E represents a ventilating shaft, and F an outlet (for the water charged with soot and other products) connected with a separating chamber, of which a series has to be used.]

Wednesday, 12th August 1891.

The President, Sir H. ROSCOE, in the Chair.

The Chemical Treatment of Sewage, with special reference to the Treatment of the London Sewage.*

BY

A. DUPRÉ, Ph.D., F.R.S.

Sewage must, in the first place, be looked upon as a material to be got rid of without injury to the population, and with the minimum amount of nuisance, without reference to any profit that might be derived from it.

The solution of the problem as to which is the best method of sewage disposal is so complicated, owing to the different conditions obtaining in different towns, that no general plan can, or should, be laid down, but each case must be treated on its own merits.

Of two plans for the disposal of sewage, both equally effective, the cheaper should be adopted.

CHEMICAL TREATMENT.—Many processes for the chemical treatment of sewage have been brought forward; but, excluding the proposed electrical treatment of sewage, which has not yet passed its period of probation, and the action of permanganate, of which more later, they may all be said to depend on the action of certain salts of alumina and iron, with or without the use of caustic lime.

The main effect of such chemical treatment is the more or less complete clarification of sewage, together with the removal of a certain proportion, generally a small one, of matters held in solution.

The character of the effluent, in some measure, depends on the condition of the sewage. Fresh sewage yields a better effluent than foul sewage; consequent necessity of some further treatment.

* This is the Abstract of a Paper which, owing to the Author's illness, could not be prepared for the Congress in full.

London Sewage.—*Difficulty of the Problem.*—Excessive volume of sewage to be dealt with. Size of area whence it comes, and consequent length of sewers, and foulness of sewage when it arrives at the outfalls. *System of London Sewerage.*—Collecting sewage proper and the rain-water in one system of sewers. Unsuitability of land in the neighbourhood for sewage-farming, distance from the sea. *Solution of the Problem*, as attempted by the late Metropolitan Board of Works. Chemical processes clarify, but do not remove much dissolved matter. Evil effects of excess of chemicals used. Consequent use of minimum amount of chemicals capable of clarifying the sewage. The clarified sewage deodorised by manganate and sulphuric acid. Resulting effluent, inodorous and nearly clear, discharged into the river mainly during ebb tide. Portion of the river should be regarded as a sewage-farm, does its work in smaller area, as effectively and with far less nuisance than a sewage-farm proper. Destruction of sewage in river and on farm due to living organisms, but oxygen necessary. The River Thames capable of dealing effectively with the effluent. Consideration shows that the river will be adequate to deal with effluent for some time to come. This period can be prolonged by the proper use of manganate. Beneficial effects on river of proposed treatment of sewage greater than the mere removal of suspended matter would seem to indicate. Destruction of dissolved matter goes on more or less all the year round. Destruction of suspended matter greatly retarded during cold weather, and nearly the whole year's production has to be destroyed during summer.

Summary.—The plan adopted is far the cheapest. It will dispose of the London sewage, without nuisance, until London has increased to from 8,000,000 to 10,000,000 inhabitants.

When that time arrives, only the sewage in excess of the quantity capable of being dealt with by the river, will have to be differently dealt with, with a corresponding reduction in cost compared with that which would be necessary if the entire sewage had to be so dealt with.

Capital, once expended, fixes the minimum yearly expenditure; outlay for chemicals can be increased or diminished according to circumstances; hence annual cost can be controlled.

Chemical and Physical Processes employed in the Treatment of Sewage.

BY

John C. Thresh, D.Sc., M.B., &c.

The few remarks I have to make in introducing this subject will refer exclusively to water-carried sewage.

The character and composition of such sewage need not be dwelt upon, and the causes of its variation in character, &c. in different towns

requires only to be alluded to briefly. In the majority of towns the sewers convey domestic sewage, manufacturing refuse, and rain and storm water. The domestic sewage may or may not include human excrement. The manufacturing refuse will vary in character with the staple industry. The rain and storm water chiefly affects the sewage by increasing its volume in proportion to the rainfall, and this occurs at irregular intervals. To avoid this disturbing element of variation in quantity, many towns recently sewered have adopted the "separate" system of sewerage, conveying as much of the rainfall as possible directly into the running streams. Where this has been done, the amount of sewage to be disposed of daily is a fairly constant quantity, and the difficulties in treating the sewage are reduced to a minimum.

The great variation in the strength and character of the sewage in different localities renders it impossible to devise any one system of treatment which shall be universally applicable. Moreover, the degree of purification required is not constant. Where the sewage can, with safety, be cast into the sea, or into the estuary of a tidal river, purification need not be nearly so complete as when its only outlet is into a stream which, a little lower down, furnishes the water-supply to the towns and villages on its banks.

The deleterious matters contained in water-borne sewage are chiefly "organic," and of two kinds, soluble and insoluble, the former being, of course, in solution, and the latter in suspension. The insoluble portion, again, may be divided into (*a*) living organisms: bacteria, &c.; and (*b*) dead organic matter.

The relative importance of these constituents of sewage in reference to its purification is a subject which admits of considerable diversity of opinion. It will, however, be admitted by all that where the effluent must pass into a stream furnishing the water-supply to communities lower down along its course, no system of treatment will be satisfactory which does not remove entirely any specific organisms which may be present, and all the suspended impurities. The dissolved organic matters also must be reduced to a minimum by precipitation, oxidation, or in some other way. To effect this a combination of processes is usually resorted to, physical and chemical. A classification of these is a somewhat difficult matter, inasmuch as certain groups overlap the others; but the following will, probably, answer every purpose:—

1. Subsidence—
   (*a.*) With complete rest.
   (*b.*) During slow, but continuous, flow.
2. Mechanical straining and filtration.
3. Chemical filtration; or percolation through materials exerting some chemical, or catalytic, action on the organic matters.
4. Precipitation by the addition of one or more chemicals. These may be—
   (*a.*) Soluble, as the salts of iron and alumina; or
   (*b.*) Insoluble, as clay, magnetic oxide of iron, and the various kinds of charcoal.
5. Electrolysis, or purification by electrical treatment.

6. Oxidation and destruction of the organic matter by addition of chemicals.
7. Sterilization and disinfection by the destruction of micro-organisms, and the arrest of putrefaction.
8. Nitrification, or the destruction of the organic matters by the action of the nitrifying organisms found in surface soils.
9. Irrigation, or the utilization of the organic matter as food for growing crops.

In exceptional cases only is any one of these processes alone found to yield sufficiently satisfactory results. To attain such results, two or more of them must be used in combination or in succession. Thus, after the addition of chemicals to effect precipitation, the precipitate must be removed either by subsidence or filtration, or by both, and the effluent may even require further purification, either by percolating through land for "nitrification," or through specially prepared chemical filters. Even where the sewage is passed onto the land, a preliminary straining or filtration, or a partial clarification by subsidence, is frequently resorted to; where it is not, the land itself will act as a mechanical as well as a chemical filter.

The various groups of processes may now be referred to *seriatim*.

1. *Subsidence.*—Practically, this is only applicable as a preliminary to some other mode of treatment, or after such treatment, or when the sewage is turned directly into the sea or a tidal river. When sewage is allowed to stand, the grit brought down from the roads after rain settles somewhat rapidly, carrying with it a little of the insoluble organic impurity. The remainder of the suspended matter falls so slowly that active putrefaction commences long before clarification is complete. After the addition of certain precipitating agents, the suspended particles fall more or less rapidly. Most rapid clarification takes place in sewage which has been rendered strongly alkaline by the addition of lime, and in which, by a judicious selection of chemicals and proper agitation, the precipitate is flocculent in character. When magnesia salts are added, a much smaller amount of lime is required to produce large flocculi. In other cases, insoluble substances, such as clay, ground coke, &c. are added, and, in subsiding, the particles carry down with them more or less of the previously suspended matter. The rapidity with which the insoluble matters subside is of importance chiefly as affecting the size of the tanks necessary for treating a given quantity of sewage. Subsidence takes place most rapidly, *cæteris paribus*, when the fluid is allowed complete rest. The slowest of motions along a tank retards the process. Very frequently such tanks are provided with screens, floats, dividing walls, &c., which, from their arrangement, retard still further, instead of accelerating, the deposition of the suspended matters.

2. *Mechanical Straining and Filtration.*—Straining, of course, is only intended to remove the coarser matters which are washed down the sewers. Filtration, on the other hand, attempts the removal of all suspended impurities. Sewage, unless previously treated by some chemical or other process, filters very slowly, and rapidly clogs up the pores in

the material used, whether this be sand, or charcoal, or earth. Most filtering materials, however insoluble in character, seem to be capable for a time of removing, not only the suspended matters, but a portion of the dissolved organic matter also. With the ordinary sand and gravel filter this action is slight and soon disappears, and mere filtration through such materials does nothing more than clarify the sewage. The number of micro-organisms may be enormously reduced, but inasmuch as the soluble constituents of the sewage are unaffected, multiplication of the remaining organisms occurs with increased rapidity. No practicable system of sewage filtration can be relied upon to remove specific organisms or to sterilize the fluid. For the above reasons, filtration, *i.e.*, mechanical filtration, can only be considered of real service as an adjunct to some other process.

3. *Chemical Filtration.*—This term is employed, for lack of a better, to the filtration of sewage through materials of an insoluble nature, which, however, possess the power of withdrawing from solution, or otherwise of destroying, certain of the organic constituents. Animal charcoal is the type of such material, and the decolourization of a solution of caramel and the removal of alkaloidal bodies from solution when the fluids are passed through it are typical of the action of such a filter. The Rivers Pollution Commissioners found that filtration through either sand or a mixture of chalk and sand could purify a certain amount of sewage, and that the process was "essentially one of oxidation, the "organic matter being to a large extent converted into carbonic acid, "water, and nitric acid." Certain compounds of iron and manganese possess this power of causing oxidation in a very much higher degree than sand or chalk. Besides this action, however, substances like charcoal act by withdrawing certain organic matters from solution, by absorption or occlusion without at the same time necessarily causing their destruction. This action, however, is limited, and of little practical utility in sewage purification. Spongy iron, magnetic carbide of iron and polarite (which consists chiefly of magnetic oxide of iron) are the materials commonly employed in chemical filtration. When the filtration is intermittent, so as to allow of frequent aeration of the filtering medium, the action continues for a considerable period. Experiments which have recently been made with polarite filter beds seem to indicate that this substance retains its oxidizing powers for an indefinite period. When sewage has been previously treated either by subsidence or by some process of precipitation so as to remove most of the suspended matters, and as much as possible of the dissolved organic impurities, the clarified sewage passes rapidly through the polarite filter, and if the latter is properly constructed, a very considerable proportion of the remainder of the organic matter is oxidised, and the effluent attains a standard of purity "greatly exceeding that prescribed by the Rivers Pollution Commissioners." This process is now at work at Acton, near London, and at Swinton, near Manchester, and appears to give most satisfactory results.

It is highly probable that this combination of processes—precipitation, subsidence, and chemical filtration—will in the near future be regarded with the greatest favour.

4. *Precipitation Processes.*—These processes are so well known that it will be unnecessary for me to do more than indicate the principles upon which they are based. Precipitating agents are added for two purposes—to cause rapid precipitation of suspended impurities, and to remove as large a portion as possible of the impurities in solution. The number of materials and of combinations of materials which have been recommended or patented for purifying sewage by precipitation is very great. Few of them, however, have proved of practical utility. The salts of iron and of aluminium, with or without the addition of lime, are the chemicals now most frequently employed, and these yield the most satisfactory results. In very few instances, however, is an effluent produced of sufficiently high standard to permit of its being cast in large volume into a running stream. To effect this, further purification by chemical filtration, or sterilization, or oxidation must be resorted to. The London sewage, for example, after being precipitated is, during the hot weather, further dosed with an acid solution of potassium permanganate to oxidize the more putrescible constituents which have escaped precipitation. There is, however, another important series of precipitation processes which aims at the further purification of the sewage by the absorption or occlusion or destruction by oxidation or reduction of the organic matter which would otherwise remain in solution. The best known of these processes is probably that designated the ABC, from the initials of the three principal substances—alum, blood, and clay—used as precipitation agents. Here the blood, charcoal, and clay added are said to act as absorbents, and to carry down with them certain substances which would not be removed by the aluminium salts alone. Drs. Dewar and Tidy, who recently reported on this process, state "that it precipitates "60 per cent. of the organic matter in solution, and of the residue left "in the effluent at least two-thirds are non-albuminous, and, therefore, "of a nature less liable to putrefactive and other changes." The International Sewage Purification Company treat their sewage with "ferrozone" (a fancy name for a mixture of magnetic oxide of iron with salts of iron, alumina, and magnesia). A process of oxidation is said to accompany that of precipitation, but the effluent is further purified by being passed through a polarite filter bed.

Mr. Hanson uses as precipitants a mixture of lime and black ash-waste. The latter is said to contain a considerable amount of sulphites and hyposulphites, which, from their powerful reducing action, greatly improve the character of the effluent.

5. *Electrical Treatment.*—Quite recently Mr. Webster has patented a process for purifying sewage by electricity. The sewage is caused to travel along a trough in which are placed iron plates connected with the positive and negative terminals of a powerful dynamo. Water is decomposed together with, so it is stated, a certain portion of the sodium chloride present in all sewage. Iron enters into solution, and then precipitates a portion of the organic matter from solution, at the same time carrying down with it the suspended matters. A further portion of the organic matter is supposed to be oxidised by the nascent oxygen and chlorine oxides produced. The amount of sludge formed is said to be smaller than in any precipitation process, and

the effluent to be purer, rendering further treatment by filtration unnecessary "except to remove sentimental objections." The process has been experimentally tested at Crossness (with the London sewage) and at Salford, and the experts employed have given very favourable reports in both places. Extended series of experiments on a much larger scale are, however, necessary to convince the sceptical that this is other than a roundabout way of producing a soluble iron salt to act as the precipitating and purifying agent.

6. *Oxidation of Organic Matters by Chemical Agents.*—Attempts have frequently been made to destroy the organic matter in sewage by oxidising agents such as potassium permanganate, but the success hitherto has either been limited, or the expense prohibitive. Patents have also been taken out for oxidising sewage by forcing air through it. Something more, however, than mere contact with air seems to be necessary for the oxidation of the organic matter. From experiments made on a small scale in my laboratory, I found that a current of air passed through a sample of sewage for three hours, possibly the maximum of time during which sewage could be retained in the works for such treatment, produced practically no effect upon it. The suspended matter did not afterwards subside more rapidly, neither was the dissolved organic matter reduced in amount or apparently altered in quality.

7. *Sterilization and Disinfection.*—In this group of processes the removal of dead organic matter, whether in suspension or in solution, is only a secondary consideration, the object being to destroy, as far as possible, all micro-organisms, and so to prevent or retard putrefactive changes. Most of these processes are used but temporarily to prevent nuisances arising in the hot weather. Chloride of lime, carbolic acid, permanganate of potash, and many other substances have been recommended for this purpose. The practical utility of any such process, except as a temporary expedient, is more than doubtful. Unless sterilization is complete the surviving organisms will rapidly multiply, and even where the effluent is absolutely sterile it may contain a large amount of organic matter which, when poured into a river, will serve as pabulum for the organisms in the river water and cause their abundant increase. No doubt it would be a great point gained were we able to prevent specific bacteria from entering our streams with the sewage, but its importance is often greatly exaggerated. The water of streams exposed continually to the action of air and light does not seem to be a favourite habitation of such organisms, and it is probably much more important to avoid polluting the streams so as to render them tolerant of such visitors than to merely attempt to keep them out at those points where the processes can be adopted. A process which, whilst removing the maximum of organic matter from the sewage, would render it also sterile and otherwise innocuous would be the perfection of sewage treatment. Sterilization appears to be most completely effected by the "Amines" process, consisting essentially in the treatment of the sewage with a mixture of herring brine and milk of lime. The brine or some body formed by the action of the lime thereon

acts as the bactericide, and the lime as a precipitant. The effluent resulting from this treatment, though sterile, is alkaline, and contains much organic impurity in solution.

Some time ago a metropolitan committee recommended the addition of disinfectants to the sewage in the house drains and small sewers to prevent putrefaction and evolution of gases. From time to time patents have been taken out and suggestions made to enable each house to treat its own sewage before casting it into the sewer. Such arrangements may prove of service in isolated buildings with their own system of sewers, unconnected with any other system, but in other cases the advantages are problematical.

8. *Nitrification.*—In the process known as "intermittent downward filtration through land" the sewage is purified (*a*) by mechanical filtration, (*b*) by chemical action of the oxygen occluded in the soil, and (*c*) by the action of the living nitrifying organisms found in all fertile surface soil. On all hands it is now conceded that it is far preferable to filter the sewage mechanically or to remove suspended matter by precipitating agents before passing it through the soil. As a mechanical filter the pores of the soil more or less rapidly become choked, and the rate of filtration is in proportion reduced, aeration is rendered more difficult and less perfect, and the oxidizing action diminishes in energy. Properly prepared soils possess in a most marked degree the property of purifying sewage. The action is essentially one of oxidation effected in part by the oxygen occluded in the pores of the soil and in part by the action of certain organisms which occur in great abundance in such soils. The relative importance of these actions in the treatment of sewage is a matter concerning which much uncertainty exists, but the balance of evidence is probably in favour of the organisms discharging the most important functions. Müntz, in a recent communication to the French Academy, states that he regards "the work of the "nitrifying organisms as confined to the oxidation of nitrogenous "matter to nitrites," the further change of nitrites into nitrates being effected by the action of the oxygen and carbonic acid in the soil. Warrington, as a result of his recent researches, includes the following in his summary :—

1. The nitrification occurring in a mass of aerated soil is purely nitric in character. Soil readily converts a solution of nitrite into nitrate.
2. Pasture soil produces nitrites more readily than arable soil.
3. A clay subsoil, down to four feet from the surface was found to produce nitrates.
4. The nitrification effected by soil is thus explained. It is performed by two organisms, one of which oxidises ammonia to nitrites, while the other oxidises nitrites to nitrates.
5. In soil, the nitric organism is equally as active as the nitrous.
6. The nitrous organism requires no organic matter for its nutrition.
7. The presence of ammonia is a great hindrance to the action of the nitric organism.

From the above results it appears probable that these organisms act almost exclusively on the ammonia of the sewage, oxidizing it to nitric acid. With too concentrated a sewage the influence of the nitric organisms may be diminished, and nitrites appear in the effluent. The nitrous organism is, however, capable of producing nitrous acid in solutions of asparagine, milk, urine, and urea; the last mentioned being the most difficult to attack. Further researches in this direction are required to ascertain by what means the organic matter is decomposed in the soil into ammonia and carbonic acid. Probably, as the *micrococcus ureæ* splits up urea, so other similar organisms may be able to decompose the more highly complex nitrogenous constituents of sewage.

9. *Utilization of Sewage as Food for growing Crops, or Broad Irrigation.*—For the first time I have had to make use of the word utilization, for by broad irrigation only can raw sewage be put to any practical use. In many of the processes enumerated there is produced a sludge which innumerable attempts have been made to convert into a manure of sufficiently high fertilising power to command a sale in the market. None of these, however, have met with any great measure of success.

Whilst nitrification or intermittent downward filtration through land merely oxidises certain constituents of the sewage to nitrates, and the latter run to waste, in broad irrigation a certain portion of the nitrate so produced is assimilated by the crops grown on the farm. The proportion of the nitrogen so utilised varies considerably, not only on different farms, but on the same farm from time to time. Yet if only half the nitrogen can be saved, it is a larger proportion by far than can be abstracted and utilised by any other process.

Broad irrigation, as at present conducted however, does not seem to offer a final solution of the problem, how best to dispose of our sewage? In a few instances only has sewage-farming proved a success. With exceptionally favourable soil and situation such a farm may continue to be remunerative for many years, but it seems very probable that there is a limit to this period. Yet such a farm, even if it does not pay expenses, may still prove much more economical than a process of sewage treatment requiring costly plant and machinery, and a large annual expenditure in labour and in chemicals, and producing nothing but an unsaleable manure.

Apart, however, from the question of expense, many objections have been raised to sewage farms on sanitary grounds. And here again, as with everything else connected with this subject, opinions diametrically opposed are held and expressed. By one party it is said to give rise to offensive and injurious emanations, to pollute the subsoil water, and to favour the distribution of the ova of entozoa; whilst others assert that in a properly-conducted farm there are no such emanations, that the subsoil water is not polluted more than by the application of any other manure, and lastly, that there is no shadow of proof that disease attributable to entozoa has ever been due to the consumption of vegetable or fruit from a sewage farm.

I have now mentioned all the processes of practical value in sewage treatment, but there are many others, such as those necessitating distillation, freezing, &c., which are so obviously impracticable that it would be a waste of time even to enumerate them.

Do any of the processes mentioned, or any combination of such processes, enable us to get rid of our sewage in such a way as to give rise to no nuisance, cause no danger to health, and this at a cost sufficiently reasonable, considering the importance of attaining such results? This is the question I would submit to the Members of this Congress.

The Duty of a Locality to Utilise the Nitrogenous Matter in its Sewage for the Benefit of the Nation.

BY

ALFRED CARPENTER, M.D.

The object of this paper is to show that localities have duties to the nation to which they belong. It is not a sound argument to assert that the performance of these duties may have an apparently adverse result for the time being, by causing considerable expense. Some other course may possibly save the local authority an immediate capital expenditure, but if that course be persevered in, it may lead to much loss and mischief to the nation. The transportation of felons (the refuse of society) to the other side of the world, appeared for the time to save this country much trouble, but perseverance in that course would have involved disastrous results. In the case of sewage refuse, when the land is deprived of its natural requirement agricultural exhaustion ensues. It is one of the laws of nature that plant life is required for the support of animal existence; and the converse is also true, that growth of animal matter is necessary for the continued development of vegetable produce. The fruits of the earth, which are especially wanted for human subsistence, require for their rapid growth the continued or occasional application of ammonia, and various other salts, in addition to carbonic acid. As the density of population increases, the safety of the people requires that the land should have greater and more rapid powers of reproduction, and nature has not been regardless of this postulate. It is quite possible for a thickly peopled district to provide food for all its inhabitants without importing food stuffs. France, Holland, and Belgium, and more especially China, India, and Japan, are instances in point. It is true that famines have arisen, as the result of war or of extreme meteorological conditions, but the fact remains, that excluding these influences, the land has grown, and can grow, produce sufficient to support a densely peopled district. This has been brought about by the careful application of the excreta of the people to the soil itself, and a high

state of cultivation has procured large crops for the use of the inhabitants, while at the same time they have been preserved from the incidence of pestilence.

In consequence of the increase of wealth, and from other causes, such as the necessity for protection against the inroads of barbarians, or when a feudal baron had to protect himself against his next neighbour, people surrounded themselves with high walls, giving up in this country the habits of their Celtic and Saxon ancestors, who had wiser plans for the disposal of human excreta than their Norman successors. Human refuse then began to be stored in pits and cesspools, by which the subsoil in the towns and their immediate neighbourhood was polluted, and the progress of epidemics assisted whenever the meteorological conditions required for their manifestation arose.

The earliest hygienic indications which are found on record are in the Bible. Moses, the great Hebrew law-giver, ordered that human excreta should be conveyed to the earth, without the camp, and after the settlement in the land of Canaan, without the city, and all polluted articles, either of clothing or anything else, well washed with water. This law, established by a despotic authority, involved two points, 1st, the agricultural use of human excreta and its immediate conveyance to the soil; and 2ndly, the absolute necessity of an abundant supply of water.

As cultivation of the soil was the main source of wealth to the Hebrews, they soon became wealthy, and with riches came indolence and neglect of the laws laid down by Moses. They allowed their dwellings to be polluted, and prepared the way for their own overthrow by agents styled in Holy Writ "the armies of the living God." That is to say, the murrain among their cattle, the blasting, or blight, and mildew upon vegetation, with the palmer worm, the canker worm, and the caterpillar. These were clearly the disease germs which have only been scientifically demonstrated in recent years. It has been proved that their powers of multiplication are promoted by soil, air, and water polluted by human excrement, and when these pollutions are prohibited by authority, and their causes prevented, the locality which expends the necessary capital is ultimately repaid a thousandfold.

Coming to our own time, I venture to assert that a rate of a shilling in the pound, if judiciously dealt with, may be incurred with the certainty that its value will come back again. It is necessary that this expenditure should be general throughout the country, in order that complete results may be obtained. The law in this country has now decided that one locality shall not pollute another by casting its refuse outside its own boundary. It has come to pass that the cost of sanitary works, though great in the first application, has, in those districts where it has been judiciously applied, been productive of immense pecuniary benefit in the saving from sickness, incapacity from depreciated mental and muscular power, and early death. But while recognising the law as to cleanliness, the country generally has not awakened to the mischiefs which result from a neglect of the other portion of the ordinance. Human excreta is not as a rule conveyed to the soil, but impediments are placed in the way of its utilisation in this manner by many land-

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owners and local authorities, with the result that agricultural produce is correspondingly diminished, and while population is increasing the people are rendered more and more dependent upon foreign countries for their food supplies. For more than 800 years human ordure has been mainly buried in the earth or passed away into the sea, or, worse still, into our running streams. By these means "the armies of the living God," the disease germs of modern times, have destroyed millions of people in the prime of life, and nature has been avenged for the neglect of sanitary law. Every human being discharges daily so many grains of phosphatic salts, and of material which becomes ammonia. Ammonia if not at once agriculturally utilised is reduced to its elements, carbonic acid nitrogen and water, thus losing 95 per cent. of its agricultural value, while the phosphates remain locked up in the cesspit, or pollute our water supplies. Phosphates are wanted for our wheat and other crops, and should be returned to the soil in the form in which they exist in human excreta. Had this been done, as ordered by our earliest authority on hygienic law, the constant re-application of the salts would have reacted, on the principle of small profits and quick returns, to the immense advantage of the people of the land.

There are several denunciations in Holy Writ, usually omitted in our public services, against those who pollute the walls of the city by micturition. No one can pass along the streets of any town or village in the kingdom, after 10 o'clock at night, and especially after the public-house closing hour, without witnessing the continuance of this act in our own time. I cannot exaggerate the evil, or say too much to draw the attention of local authorities to the mischiefs which result from the continuance in our cities, towns, and villages, of this indecent habit. Its denunciation in Scripture is not, in my opinion (as generally supposed), intended to indicate a judgment upon the people at large, but for the purpose of pointing out a breach of sanitary law in which the drunkard and the profligate indulged in Israel, as much as they do in Britain to-day. By this act the passer-by soon after may inhale a material capable of providing a forcing bed for disease germs, and allowing of the production of some of those forms of influenza and other catarrhal disorders which are so puzzling to the student in the etiology of epidemic disease, and are often the basis on which is established organic disease. These offences against decency are offences against the health of the community, and are taking from the nation a power to return to agriculture that which is required for the nation's welfare, for the larger part of the agricultural value of sewage is found in the urine. The denunciation of this act in Scripture is therefore called forth by a disobedience to hygienic law.

The habit helps to spread infectious disease. It also prepares the way for famine by removing from their proper place ingredients required for the nourishment of plant life in their most available form. It is often said that it will not pay a locality to utilize its sewage in the manner which I advocate, that to spend a sovereign in a way only likely to bring back ten shillings is economically wrong. This might be so if there were no other contingencies to be considered. But let me put before you the results of sanitation in my own town, Croydon. A death-rate of

26 per thousand and a rating equal to 6*s.* in the pound, more than 35 years ago, was followed by the capital expenditure of some 600,000*l.* in sanitary works for a population of 36,000 persons, gradually increasing in numbers as the expenditure went on. The death-rate has averaged, for the past 10 years, 14 per thousand, and the rating is at this moment 5*s.* 4*d.*, though, in addition to a high Metropolitan Police rate, a School Board, public baths, public libraries, and nine public parks for the recreation of the people have been established in the district. The expenditure on sanitary works gives a beneficial return to the locality as well as to the nation, and has added much wealth to the district in which the works have been carried out.

The people of Croydon have expended some 230,000*l.* in the purchase of land for the purpose of sewage utilization during the past 30 years. They were prohibited by law from fouling the Wandle river, and injunctions obtained against the local authority before the year 1860 have never been dissolved, yet the effluent from the sewage farm has been discharged into the Wandle, and the authority has been unmolested by law ever since they applied the sewage to the land in the manner which is termed broad irrigation, while the cost to the ratepayers (exclusive of the purchase of the land) has never exceeded a twopenny rate. What have we had for this rate? Improved health, the employment of a large number of hands at improved agricultural wages, exceeding by five times the number formerly employed on the same land, a large increase in the amount of meat and milk at the service of the people, and, so far, the nation ensured against the chance of evil from scarcity. Surely these results are far in excess of the burden imposed. It is, in my opinion, a national mistake to allow the continuance of waste in the face of such national advantages.

Let me now turn to the condition of the Thames. It receives the sewage of the metropolis, which is treated chemically at an immense cost to the London County Council. The Croydon local authority used a lime process when the sewage was first applied to the land, it being then supposed to be a necessity of the work. Some large sums were annually expended in this operation, and nuisance was actually produced by the sanitary authority in the places where the tanks existed. These were removed some 15 years ago, and the sewage has ever since been discharged directly upon the land, without any other process than a rough straining through wire guards. The expense of treatment in tanks by the lime process has been saved, and it has been clearly demonstrated by our experience that such treatment is entirely unnecessary. If fresh sewage is discharged immediately upon the land before putrefaction has commenced, no evil will result to the locality to which it is conveyed. If sewage is kept moving at a fairly rapid rate no opportunity for putrefactive action will be given, and the sewage may be conveyed 40 or 50 miles in either closed or open courses with safety, provided that the closed mains are kept filled with moving sewage.

Let me apply the principle of this form of utilization to the sewage of London. Take the population at about 4,000,000. The average agricultural value of the refuse of each individual may be roughly

estimated as equal to that of a sheep for the same purpose. This has been put at 5*s*. per head by competent authority. Assuming this to be a minimum value, the sewage of London is worth, in the abstract, a million a year, independently of the national advantages which would result from its utilization. Let us assume, for a moment, that these advantages would justify the nation in guaranteeing the interest of 3 per cent. on 20,000,000*l*. devoted to such a purpose. If that amount were judiciously expended in promoting the Canvey Island or Maplin Sands' scheme, together with the erection of pumping stations at favourable points on the present collecting sewage outfalls, with covered rising mains conveying the sewage to high lands beyond the populous districts around the metropolis, immense areas of barren, uncultivated land might be converted into farms, producing luxuriant crops, and large agricultural populations would be provided with the means of subsistence, while increased supplies of milk, meat, and vegetables, would be at the command of the people, and, so far, there would be diminished scarcity of supplies in the event of complications with foreign nations. This would help to bring about the effects which are expected to result from the principle of allotments, now so strenuously urged upon Parliament by the advocates of healthy employment for the people. The estuary of the Thames would be freed from a condition which is a standing disgrace to a civilized community, and which, if persevered in for another half century, will inevitably damage the navigation of the river, and consequently the trade of the port of London.

Seven or eight years ago I acted as one of a committee for the erection of a third lunatic asylum for the county of Surrey. We arranged for the utilization of the sewage of 1,200 inmates by broad irrigation. The area irrigated is absolutely within a stone's throw and in front of its principal entrance. I append a letter received from the medical superintendent as to the result. I may add that the asylum has recently passed out of the care of the Surrey magistrates into the hands of the London County Council.

London County Asylum,
Cane Hill, Purley, R.S.O.,
April 4, 1891.

DEAR DR. CARPENTER,

. . . . . .

No report on the result of our sewage utilization has been recently published. The sewage, as you are aware, is disposed of here on the land by gravitation. The process is simple in the extreme, one man managing the whole affair.

1. The health of the population of the asylum is unaffected in any way. Not the slightest discomfort or nuisance arises from the land irrigated, and this although it immediately adjoins the Brighton Road.

2. Italian rye grass is grown in large quantity, and is consumed as summer feed by the cows and horses. The portion irrigated is cut for two years, then ploughed and cropped for the two following with roots (mangold) and oats.

3. Financially, there is considerable profit, as the stock would require a much larger area of land if fed by grazing, or else a large outlay for some substitute for the rye grass.

Amount of land irrigated, nine acres. Asylum population, 1,250. No effluent.

Believe me,
Yours very truly,
JAMES MOODY.

About 20 years ago, the burgomaster of Dantzig, with a deputation from the governing body of that city, visited Croydon, and inspected our sewage farm. As a consequence of that inspection and of other information afforded to them, a sewage farm has been established at Dantzig, I now publish a letter from the manager of the farm.

Danzig Sewage Farm,
DEAR SIR, September 1, 1890.

I HAVE been following, with great interest, the accounts in the "Times" of the meetings of the Sanitary Congress, and I cannot help writing you to confirm, from my experience, the views which you have expressed, viz., "the establishment of a number of sewage farms would "be better. It would be more desirable, instead of wasting the sewage, "to distribute it over an area where it could fructify. With people so "much in need of meat and milk as Londoners were, it was criminal to "destroy such a valuable means of production of those commodities." I have no doubt whatever the County Council will soon find itself compelled to do something besides polluting the seaside as well as the Thames, and no better beginning could be made than by carrying out the Maplin Sands or even the Canvey Island scheme. I am confident the result would be satisfactory, and that other sites would soon be offered or found. It is to me quite incomprehensible that the Council has taken no opportunity of viewing the Berlin sewage farms, which, despite the enormous outlay, are a most complete success. If the 1,720,000 inhabitants and ratepayers are *quite* agreed as to this, surely it is worth while looking at. Our farm here in Danzig has been visited this year by a great number of authorities from all parts of the world, exciting wonder as well as interest, for year by year the results are more satisfactory, financially as well as agriculturally. Only last week we entertained a large party of visitors from Austria, who were very much astonished to find whole plantations of Edelweiss, and to drink the capital red currant wine which is so much esteemed here, produced on the sand of the sea shore by the utilization of the Danzig sewage. Asparagus continues to be one of the best paying products, and commands a much higher price than that produced on the inland farms.

Yours respectfully and faithfully,
Alf. Carpenter, Esq., M.D. ALEX. AIRD.

In addition, I may add the testimony given by Dr. C. E. Saunders, Medical Superintendent of the Sussex County Lunatic Asylum. When the congress of the Sanitary Institute was sitting at Brighton last year he invited the members to view the irrigated land at Hayward's Heath. He stated that the food grown upon the farm had all been consumed, directly or indirectly, within the asylum, and he pointed to the com-

paratively low death-rate at the asylum, and the absence of all zymotic maladies as a clear proof that the food used was free from all disadvantages.

I propose to deal with the objections that have been made on sanitary grounds to sewage farming in a second paper.

The Power of Soil and Vegetation combined to destroy Disease Germs, and so to prevent the Possibility of the Spread of Enthetic Disease in consequence of Sewage Farming.

BY

ALFRED CARPENTER, M.D.

At the meeting of the International Medical Congress in London in 1881, I had the privilege of introducing to the notice of the members the subject of sewage utilization by means of irrigation. I submitted nine propositions, and the evidence upon which those propositions were based, viz., the practical experience of 21 years' personal observation upon the Croydon sewage farms. A further experience of 10 years gained by closely watching the same farms (the areas being increased) has fully confirmed every word put before the great assembly of 1881. No essential part of that evidence has been successfully assailed, and every word might be repeated here if it could be done without loss of time. I will renew the propositions, so far as they bear on the power of soils to destroy the germs which in other positions are capable of spreading infectious disease.

Proposition 1.—That the judicious application of sewage in close proximity to dwelling-houses does not depreciate the health of the inhabitants. A continuation of the table then given of the vital statistics of the parish of Beddington and of the hamlet of Wallington will afford proof of this contention.

BEDDINGTON.

—	Population.	Rateable Value.	Births.	Deaths under 1 year.	Deaths over 60.	Total Deaths.	Birth rate.	Zymotic Disease.	Death rate.
		£							
1882 - -	2,485	17,689	64	6	3	18	25·7	None.	7·2
1883 - -	2,531	18,532	76	10	9	31	30·	None.	12·2
1884 - -	—	19,120	76	8	8	27	—	3	—
1885 - -	—	19,258	62	5	4	26	—	2	—
1886 - -	—	19,684	78	9	8	31	—	6	—
1887 - -	2,950	20,325	72	8	8	25	24·4	2	8·4
1888 - -	3,000	20,260	72	4	5	23	24·	1	7·6
1889 - -	3,050	20,156	58	3	3	12	19·	None.	3·9
1890 - -	3,250	20,216	61	6	6	16	18·7	2	4·9
1891 - -	—	20,203	—	—	—	—	—	—	—

WALLINGTON.

—	Population.	Rateable Value.	Births.	Deaths under 1 year.	Deaths over 60.	Total Deaths.	Birth rate.	Zymotic Disease.	Death rate.
		£							
1882 - -	3,007	21,912	89	12	10	43	29·5	None.	14·3
1883 - -	3,033	22,578	75	5	8	31	24·5	None.	0·1
1884 - -	—	23,217	92	10	8	33	—	2	4
1885 - -	—	23,888	85	9	19	48	—	2	—
1886 - -	—	25,870	110	8	14	33	—	1	—
1887 - -	4,900	26,172	101	9	7	35	20·5	4	7·1
1888 - -	5,500	26,126	72	10	19	41	13·	4	7·4
1889 - -	5,600	26,176	98	8	13	37	17·5	3	6·6
1890 - -	5,900	26,707	100	10	11	35	16·9	6	5·9
1891 - -	—	26,761	—	—	—	—	—	—	—

It will be observed from this table that the population has increased in a very rapid ratio, which is the more manifest when compared with that of 1861. The census of that year gave a population for the combined districts of 1,557, and a rateable value of 11,700*l*. Notwithstanding the existence of the sewage farm within the distance of less than a mile from the extreme limits of the district, there has been a rapid increase in both population and rateable value. The high birth rate has naturally raised the death rate, quite independently of outside influences, and the zymotic rate includes diseases such as whooping-cough, which cannot be laid to the charge of the farm.

Proposition 2.—That the judicious application of sewage to land will satisfactorily cleanse the effluent water, and fit it for discharge into any ordinary rivulet or water course. Recent analyses of the Beddington effluent, show that after 31 years continuous application of sewage to the same land, there is a persistent power in that land to deal with the applied sewage as satisfactorily as was the case when it was examined by the River Pollution Commissioners in 1867, as reported to Parliament. It may be that the effluent has not been at all times equal to these analyses. Errors of management, absence of manager, great rainfall, cleansing of carriers after haymaking or grass cutting, and the flushing which has to take place after such cleansing, tend for the moment to make the effluent chemically less satisfactory; but in no case has this been more than an accident, which can be, and has been, easily remedied. I need not labour at this proposition. Its truth has been abundantly demonstrated at other places besides Croydon, though not over so long a period of time, and chemical analyses of a highly satisfactory kind have been published in the sanitary journals.

Proposition 3.—That vegetables from fields continuously irrigated by sewage are satisfactory food for man and beast; that animals fed mainly on sewage produce are as healthy as animals fed on ordinary agricultural produce. I prove this by the emphatic statement that no evil effects have been shown to have followed from the consumption of the food which has been grown upon the 600 acres of land irrigated by

the Croydon sewage, or on the 1,200 acres irrigated by the Birmingham Corporation. The immense quantities of food in the way of meat and milk resulting from these large areas must have shown evidence of their unsoundness, if any had really existed. If, in addition to this, I take the evidence afforded by medical superintendents of lunatic asylums, such as that given in September by Dr. C. E. Saunders at Haywards Heath, and Dr. Moody at Cane Hill, it will not be necessary to write more to refute the imaginary notions of those who assume that sewage-grown produce must be unwholesome.

Proposition 4.—That excretions of those suffering from infectious and epidemic disease, when distributed upon land, as in broad irrigation, are immediately rendered innocuous. If rightly dealt with they cannot spread such diseases to those employed on the farm, or injure those who consume the produce, or set up similar disease in those living on the confines of the farm. No evidence has been adduced to contradict this proposition. I append extracts from the reports of the medical officer of health, who, acting for the rural sanitary authority, was not under the jurisdiction of the Croydon authority, and therefore gave an independent opinion.

Mr. Cressy reported (Lady Day, 1883): "I have to report for the "year 1882, an immunity from fever of every kind. The area reported "upon includes an asylum of 170 girls from 8 to 16 years of age, which "has a remarkable freedom from zymotic disease." This paragraph refers to the Beddington Female Orphan Asylum, a building containing nearly 200 occupants, and placed at the south-west corner of the farm, separated by a small brook from fields frequently under irrigation; and a north-east wind carries with it any miasma produced by more than half a mile of irrigated land.

In 1883 there was no outbreak reported except one, which the medical officer considered to have been caused by polluted water. There were two cases of enteric fever resulting in one death.

In 1885, six cases of diphtheria were reported as arising in South Beddington, in houses at a high level on the chalk (a point the most distant in the parish from the farm) traced to local sanitary defects.

As to 1886, Mr. Cressy reports: "There has been no outbreak of "zymotic disease. A case of diphtheria did arise which was imported, "but there was no extension." Mr. Cressy, taking a survey in concluding his report says: "The district has been very free from infectious disease."

In 1887, two cases of typhoid, one being fatal, were reported, and referred to dirty hand-flushed w.c.'s. "The record, as far as infectious disease is concerned," says, Mr. Cressy, "speaks for itself."

In 1888, he says: "I find the health of my district even better than last year."

These reports corroborate the view put forth in 1881 to the fullest extent. It is true that a new medical officer of health has been recently appointed, who signalised his first report by a suggestion that as he had been unable to trace an outbreak of scarlatina in the Beddington Female Orphan Asylum, it might be produced by emanations from the Croydon sewage farm. This opinion is not supported by evidence worthy of

credence:—(1.) If it were true, scarlatina must have continuously affected the inmates of the school, and but few, if any, of the children sent there would have escaped the disease. The late Mr. Cressy's reports directly contradict this theory. (2.) There are living on the farm several families of children; most of them have not been affected by scarlatina. (3.) Considerable numbers of children at Hackbridge on the west, and at Waddon on the east, have never suffered from scarlatina; and the South Norwood district of Croydon, which is close to the South Norwood farm, has been singularly free from this disease as compared with other districts, and even with other parts of the borough of Croydon where scarlatina does not exist to anything like the extent found where there are no sewage farms. This clearly shows that the germs which promote the spread of scarlatina are not multiplied in areas devoted to broad irrigation, and it may be fairly assumed that the allied zymotic disorders are not capable of propagation from such areas, otherwise those diseases would be found to be more prevalent among the neighbouring residents than elsewhere. This is certainly not the case at Beddington or Norwood, or in the neighbourhood of any other sewage farm with which I am acquainted. Yet cases of scarlatina do occur in the borough of Croydon, in sufficient numbers for me to say that in no single month in any year have the excreta of scarlatina patients failed to reach the farm at Beddington.

Surely this evidence must be conclusive. I contend that the excreta of infectious patients are not capable of spreading infectious disease unless they have undergone a zymosis, which cannot take place if the excreta are cooled at once, aërated as they are on the surface of the soil, and brought into contact with the humus of the earth and the rootlets of the growing crops. An experience of 31 years has not produced any evidence to contradict this proposition. Sewage must be kept near to the surface of the soil so as to have the advantage of sunlight, air, and vegetable life. If sewage percolates deep into the soil out of reach of air and light, the ova of disease germs may be preserved ready for use upon some other opportunity, and possibly carried away in the effluent water. It is requisite, therefore, that ova be destroyed as well as the germs themselves. This destruction is best effected by vegetable life, and the means whereby this comes about are most numerous on the surface of the soil itself.

In close proximity to the north-western border of the farm is the populous village of Mitcham. Hear what Mr. Marshall, the medical officer of health, reported to the rural sanitary authority in the spring of this year. "Considering the amount of sickness at the beginning of the year as due to the prevalence of the influenza," and at the end of the year to the "severity of the weather, I think the mortality very moderate, "as was also the amount throughout the year of zymotic disease. "There has been in the district scarlet fever of a mild type, and only "one death is recorded."

Birth rate for year ending 31st March 1891	..	-	29·51
Death rate „ „ „	-	-	11·93

The population of Mitcham is estimated at about 12,500.

Proposition 5.—When examining into this subject some years ago, I carried out a series of observations upon the power of rye grass to deal with the organisms found in sewage. A cubic yard of soil from Beddington was placed in a container and sown with rye grass. The seeds were treated every day with sewage dressings, and the application continued until effluent appeared at the provided outlet. The applied sewage was of the ordinary character; but occasionally urine, swarming with bacteria, was added. Microscopic examination of the effluent failed to discover any of these organisms in the liquid, even after it had been kept for three days. The best time to see the reason of this exemption is about the time at which the plant comes into flower. If the surface of the field is then closely examined, it will be seen to be covered by a felt like mass of minute radicles extending from the plant at the point at which it is attached to the soil. As the sewage is applied, the rootlets seem to be endowed with life, to become mobile; the bacteria adhere to them as they pass with the sewage through the living filter, and if these rootlets are examined through a magnifying glass, the germs are seen in an hour or two to disappear from view, as if digested by the plant itself. Hence I have presumed to apply to rye grass the term carnivorous.

It is by this natural process that the ova of disease germs are removed from the sewage, and the effluent satisfactorily cleansed. A similar result occurs when vegetable life is not active. The ulmic salts in the upper part of the soil have an attraction for living organisms similar to that existing in living vegetable root fibres. This humus is only to be found on the surface of the field, and this is the reason why sewage must not be allowed to filter deep into the soil. Intermittent downward filtration is not safe in its results, because the cleansing power of the humus may be overtaken, and disease germs escape with the effluent.

A microscopic examination of the soil from Beddington, showed myriads of living organisms within the first three inches of the surface. At a depth of one foot there were found not to be more than a tenth part of those nearer the surface. At two feet deep they were much less numerous; at the depth of a yard they were sometimes absent altogether, though the surface had been irrigated, more or less, during the whole of the year preceding that in which these experiments were carried out. The bacteria found in the soil evidently feed upon the organic matter contained in the sewage, and change it into elements fitted for plant use. It is thus that nature protects us from the natural consequences of animal existence. We have only to see that the laws of the universe are obeyed, and we then escape from the incidence of those diseases which disobedience entails. At the same time we grow increasing quantities of food for those who produce the sewage.

The proposition, therefore, is—Sewage when kept in motion and quickly brought into contact with soil and vegetable life is changed in a direction contrary to that which is necessary for the propagation of disease germs. It has been asserted that parasitic diseases are spread by sewage farms. I persistently searched for evidence of this before the year 1875, and have continued my observations since. I have not

met with cases of *tænia solium*, or tape-worm, in Croydon ; there is no evidence of its existence in the case books of the medical officers reporting to the destitution authority (Board of Guardians). If cases had existed, some notice of them must have been found. I placed a mass of evidence on this point in the hands of the late Dr. Cobbold, and invited him to come down and examine for himself a large herd of oxen about to be slaughtered, which had been bred and grown on the Croydon farm. Dr. Cobbold at that time was in bad health and could not come; but, in a letter to me, he withdrew the charges he had made suggesting possible evils attendant on the establishment of sewage farms.

A microscopic examination of the flesh of those animals did not show a particle of evidence in support of the allegations.

To conclude, I have put before you a survey of every point bearing on the hygiene of sewage farming, and I claim to have proved that the utilization of sewage in the manner indicated is a national advantage.

DISCUSSION.

Sir Henry Roscoe hoped the discussion would take a purely scientific direction. He regretted the absence of Dr. Dupré on account of ill-health, as he had undertaken to bring before the Section the present mode of treatment of the London sewage. He, the President, had not been an advocate of the mode of treatment adopted by the late Metropolitan Board of Works and continued by the London County Council, and he therefore the more regretted that the subject could not be fully discussed. The President called attention to what he considered a most admirable report on sewage, which had just reached him, by the State Board of Health of Massachusetts. From the most elaborate series of experiments, both chemical and bacteriological, made upon the system of intermittent filtration, a most important fact was brought out which had hitherto been overlooked, namely, that in the process of the filtration of sewage through sand the action is not merely a straining out of the suspended particles, nor is it a merely chemical one ; but by far the most important action is a purely biological one, inasmuch as each grain of sand appears to become the nucleus of a peculiar condition of the nitrifying organism, the activity of which brings about the nitrification and purification of the sewage applied to the filter. Air is absolutely necessary for this process of purification, and hence the importance of the filtration being intermittent. He believed the Section would be interested to hear the results of this important investigation, and that the Section would congratulate this American Congress on the remarkable work which they had carried out.

Mr. H. Alfred Röchling, C.E., said: Difficulties with the Leicester sewage, where he had been connected with the public works of the town, and where since 1855 almost every known chemical process had been tried and had signally failed, had forced the subject of sewage farming upon his notice; and the Berlin farms being the largest in existence, he had very carefully inquired into their working since their establishment. The Berlin Municipal Authorities, and especially Herr Marggraff, the Commissioner of the Farming Committee of the City Council, had generously placed a large amount of information concerning the farms in his hands by supplying him with plans and the yearly

reports, from which he had abstracted the following information: The total area of the irrigation farms has now reached 18,796 acres, but of this total only 7,942 acres are sewaged at present; the rest is being prepared as necessity occurs, the drainage of the city being extended every year. The land is bought when a suitable opportunity offers, and is farmed in the ordinary way until required for the disposal of sewage. The 7,942 acres sewaged at present are all in the four original sewage farms, which have an area of 11,016 acres; nearly all the sewage-treated land is under-drained. The following details refer solely to the four original farms: In Berlin all the liquid refuse from the houses goes into the sewers and is, together with some portion of the storm-water, lifted onto the farms by powerful machinery. The two southern farms are about 12 miles, and the two northern farms only about six miles, from the heart of the town. During the year 1889-90 (from 1st April 1889 to 31st March 1890, the official year) the sewage occupied about 10 to 12 hours in traversing the distance from the pumping station to the southern farms. The subsoil on the farms is chiefly sand, passing in places to sandy loam or loamy sand. There are three different modes of applying the sewage to the land, viz., in sloping grass plots (broad irrigation); in nearly level beds (filtration); and in perfectly level tanks (filtration). In broad irrigation the sewage enters the plot at the top, fills a small trench, and flows in a thin layer down hill. In filtration the land is divided into ridges about one yard wide, separated from each other by a trench, the ridges being generally planted with root crops, and the sewage is allowed to fill the trench only, in which it has to stand, getting sideways at the root of the crops but not coming into direct contact with the plant, and filtering away into the subsoil. In winter, when the ground is frozen to such a depth as to make irrigation impossible, the sewage is turned into large earthen tanks in which it stands till it has all disappeared in the subsoil. This mode of application is limited only to times of severe frost, and the area on which it is practised is only about one-twentieth of that specially prepared for sewage treatment; as might be expected, it does not purify the sewage to such an extent as either of the other modes. The expenses in connexion with the purchase and laying out were as follows (up to 31st March 1890):—

Purchase, 40*l.* 9*s.* 9*d.* per acre; distribution of sewage, 13*l.* 9*s.* 10*d.* per acre; laying out, 8*l.* 12*s.* 2*d.* per acre; draining land, 6*l.* 1*s.* per acre; sundry expenses, 4*l.* 9*s.* 6*d.* per acre: Total 73*l.* 2*s.* 3*d.* per acre.

The total quantity of sewage disposed of on the farms since their establishment has been 350,673,798 tons; and though they have dealt with this large amount, the land does its work to-day as well as ever it did before. The farms were practically not complete till 1885, and in the first year of complete farming (year ending 31st March 1886) a profit, in management only, of 1,509*l.* was realised, whilst in the year ending March 1889, a profit of 11,511*l.* was realised. If annual payments for capital expenditure are taken into consideration, all the profit of course disappears and is, indeed, changed into a loss; but even then it took only a rate of from 0·82 to 0·97 of a penny in the £ of the rateable value of property connected with the sewers to make up for the deficiency in the years 1885-90. The total expenditure for sewerage and sewage disposal works has now reached the sum of 4,080,440*l.* Professor D. Salkowski, of the Berlin University, has carried on a systematic investigation of the effluent waters from the farms, and has made altogether 296 analyses (up to 31st March 1890); from these it appears

that grass plots (broad irrigation) have abstracted 93·89 per cent. of organic pollution—as expressed in parts of permanganate of potash—and 98·15 per cent. of organic ammonia; beds (filtration) have abstracted 92·56 per cent. of organic pollution—as expressed in parts of permanganate of potash—and 97·72 per cent. of organic ammonia; tanks have only abstracted 82·60 per cent. of organic pollution. In connexion with the sewage farms the authorities have established a perfect system of recording not only all deaths but also all cases of sickness. Between 1885 and 1889 the average population per annum on the farms was 968 men, 825 women, and 327 children, or a total of 1,580 (61 per cent. men, 18 per cent. women, and 21 per cent. children); but of the total grown-up male population of 968, 850 are "correctionists" (street loafers, &c.) impoverished in health. The death-rates per 1,000 for all classes were 11·24 in 1885, 9·22 in 1886, 14·83 in 1887, 6·79 in 1888, and 4·81 in 1889. For the seven principal zymotics the death-rates per 1,000 were 4·32 in 1885, 3·69 in 1886, 4·15 in 1887, 1·13 in 1888, and nothing at all in 1889; or, if the cases are enumerated, there were in this period (1885 to 1889) seven deaths from scarlet fever, nine from diphtheria, one from typhoid, and three from diarrhœa, all, without exception, among children under 15 years of age. In 1889 there was a somewhat severe epidemic of typhoid fever in the city of Berlin, but not one case of typhoid fever was reported on the farm.

Dr. J. H. Gilbert said that, dismissing the subject of the methods of chemical treatment of sewage as a means of purification or of utilisation, as of comparatively temporary or limited utility, he would confine his attention to the application of sewage to the land. The two questions, of purification and of utilisation, must to a certain extent be viewed separately. If the position of a town were such that sufficient land for utilisation could not be obtained or reached without prohibitive expense, in most cases enough might be available for purification to the extent necessary to allow of the effluent passing into a river. Sometimes more or less utilisation may at the same time be combined. When, however, utilisation is a prominent object much more land is essential. But if, as should be the case, the application is mainly restricted to the growth of succulent crops, the area necessary would be much less than were the arrangements made with the object of including the growth of ripened crops, which require, and will bear, much less water. At the same time, assuming the scheme to be specially adapted for the growth of succulent crops, and mainly for the production of milk and meat, more or less land might sometimes be devoted within the area to the growth of grain or other ripened crops by limited irrigation, or by the use of the manure of the animals fed, if this be not made to contribute to the sewage. So far as we at present know, the purification necessary to allow of the effluent being discharged into a river is reached when practically the whole of the soluble organic nitrogen is oxidized into nitric acid; and in our climate it would only be for short periods of the winter that this result would not be sufficiently attained under proper management. A question arises, however, whether—although all the nitrogenous compounds were oxidized—all injurious organisms would be removed, and this is a point requiring further investigation. But obviously it would be an advantage if the organisms effecting the several stages of the nitrification process were not removed, but passed into the river. There can be no doubt that, although purification is of first importance, utilisation for succulent crops, which would take up the manurial matters more

or less almost the year round, would according to the degree in which local conditions, cost of distribution, &c., permitted, greatly increase the production of the important foods, milk and meat, and more or less that of other products. Yet, it was hopeless to suppose, that by the return of the constituents of sewage to the land, our country would be able to produce all the food required by the population. Cost of distribution must limit the area irrigated and the crops grown, and there must be waste of manurial matters, more or less, according to the local circumstances. But all the produce that can be obtained is so much to set off against the essential cost of purification; though it would probably be only under very exceptional local conditions that a direct profit on the outlay for removal, distribution, and management, could be expected. Application of sewage to the land, however, was undoubtedly the best known means of purification, and, notwithstanding the necessary limitations to its general applicability as manure, so far as present experience goes, it also promised the best result so far as utilization was concerned

Colonel Jones, V.C., agreed entirely with the remarks of the President on Dr. Thresh's paper, and stated his view of the practical question, "Will a sewage farm pay?" As regards the London question, he referred to the Canvey Island scheme, and challenged Dr. Dupré and his co-fellows of the Royal Society to reply to his article in the "Fortnightly Review" for July 1886, stating that the present state of the Thames, as evidenced by the medical officer of the port of London, and a petition from Woolwich recently presented to the London County Council, was now worse than on any previous occasion.

Mr. G. H. Bremner advocated the application of a process of aëration to sewage.

Dr. C. R. Drysdale expressed his gratitude to the former speakers for their remarks, and especially to Dr. Carpenter, who might be called the father of sewage-farming in England. It was from England that France and Germany had first learnt the value of sewage-farming, but those countries had now, so far as the capitals were concerned, left us far behind in the matter. Paris and Berlin had large irrigation farms in very successful operation, and the results obtained there made it still more distressing that London should be so supine in this matter, and go on pouring 180,000,000 gallons of sewage daily into the river instead of employing that fertilising process in the raising of meat and milk for the inhabitants of London.

Mr. T. J. Perry (Camberwell) advocated the adoption of the radial method of distributing sewage as opposed to centralisation. London should be divided into 12 districts, each of which would produce about 17,000 gallons daily, storm-water being dealt with separately. Although in favour of the system of irrigation where applicable, he would not himself care to live near a sewage-farm.

Mr. W. C. Sillar defended the A.B.C. process for removing sewage, now in operation at Kingston-on-Thames, regarding it as a better and more practical system than irrigation, and pointed out the great demand for the manure thus obtained. He denied the statement that ammonia and phosphates were added to the manure to increase its value.

Dr. C. E. Saunders insisted on the absence of nuisance or other dangers to health in the proximity of a sewage farm when the sewage is properly dealt with by broad irrigation. He objected to the introduction

of a commercial element into the discussion, as the scientific aspect of the case should not be mingled with the commercial.

Dr. Alfred Carpenter stated that the crude matters are first removed from the Croydon sewage, and the latter then passed directly on to the land. With regard to the statement that people would not care to live near a sewage farm, he pointed out that there were many villas around the Beddington farm.

Dr. E. Haughton was prepared to provisionally support the use of sewage by spreading it over sewage farms, but did not consider all localities suitable for the purpose, and hoped the day would come when the dry method would be perfected, and the so-called sewage system would be superseded by the no-sewage system.

Alderman Boulton (**Corporation of Burslem**) stated that the irrigation system had been adopted at Burslem with great success, but deprecated the fact that the land obtainable for this purpose was always sold at much higher than the market price.

Mr. Cripps (**Tottenham**) pointed out that the system mentioned in Dr. Thresh's paper as being in use at Tottenham had now been given up, and that Tottenham had paid a fine of 30,000*l.* to join the Metropolitan sewage system.

Thursday, 13th August, 1891.

The President, Sir H. Roscoe, in the Chair.

Kritische und experimentelle Studien über die hygienische Bedeutung des Kupfers.

VON

Professor Dr. K. B. Lehmann, Vorstand des hygienischen Instituts, Würzburg.

Seit der Mitte des vorigen Jahrhunderts beschäftigt die Kupferfrage die wissenschaftliche Welt. Bis zu den fünfziger Jahren dieses Jahrhunderts war das Dogma von der hohen Gefährlichkeit des Kupfers trotz vereinzelter Widersprüche unbefangener Beobachter (z. B. Ellert) allgemein acceptirt, dann folgte eine gewaltige Reaction, die in dem Satze gipfelte: "*Kupfer ist kein Gift.*" Namentlich Erfahrungen practischer Aerzte über die Ungefährlichkeit der Anwendung selbst hoher Kupferdosen bei der Behandlung von Croup waren unvereinbar mit der Lehre von der hohen Giftigkeit.

Die sorgfältigen Arbeiten der letzten Jahrzehnte, unter denen namentlich die von Toussaint, Galippe und Du Moulin genannt sein

mögen, haben weitere Klärung gebracht. A. Gautier's verdienstvolle Schrift "Le Cuivre et le Plomb" hat in weiteren Kreisen maassvolle Anschauungen über die wahre toxicologische Bedeutung des Kupfers zu verbreiten gesucht.

Derselbe Autor hatte auch mit Bouchardat auf dem hygienischen internationalen Congress in Paris 1878 die Reverdissagefrage zu behandeln, die er im Sinne eines Compromisses zu lösen vorschlug: Es sollten bis 18 mg. Kupfer (die gerade für Erbsen hinreichende Menge) pro Kilo Gemüse zugelassen werden. Da Bohnen mehr Kupfer zu ihrer Grünfärbung bedürfen, als Erbsen, so sind jetzt, meines Wissens, 40 mg. Kupfer pro Kilo Gemüse in Frankreich zugelassen.

Aber trotz dieser Aufklärungen findet man noch in den weitesten Kreisen Unklarheit in der Kupferfrage. Wie weit die Ansichten unter hervorragenden Aerzten und Toxicologen noch auseinander gehen, bewies aufs Klarste die fast endlose Debatte der belgischen Academie 1884, die über die Frage des Ministers entbrannte, ob ein Kupferzusatz zu Nahrungsmitteln als gesundheitsschädlich zu betrachten sei.

Du Moulin vertrat, von einigen Collegen unterstützt, die These: "Kupfer ist kein Gift" bis in alle Consequenzen, wurde aber von der Mehrheit überstimmt. Doch gingen die Ansichten seiner Gegner weit auseinander, es fanden sich alle denkbaren Abstufungen der Beurteilung des Kupfers von der ächten Cuprophobie bis zur kritischen Würdigung der wirklich nachgewiesenen Schädlichkeiten neben einander vertreten. Der Beschluss lautete: "Es sei dem Minister zu empfehlen, jede " Anwendung von Kupfersalzen zu Speisezwecken zu verbieten, da sie " schädlich seien."*

Die Darstellung aller Autoren leidet unter dem in der Litteratur stets hervortretenden Widerspruche:

So viele therapeutische und experimentelle Erfahrungen scheinen eine relative Unschädlichkeit des Kupfers bewiesen zu haben, daneben enthält bis in die allerneueste Zeit die Litteratur fortwährend vereinzelte Berichte über schwerste akute Vergiftungen durch relativ geringfügige Kupferdosen. Die Unsicherheit der Verfasser der Lehrbücher tritt auch in den gerichtsärztlichen Gutachten immer wieder zu Tage. Auch die Frage der chronischen Kupfervergiftung wird von den meisten Autoren ohne rechte Ueberzeugung verhandelt.

Bei diesem Stande der Frage schien es mir erspriesslich, mit einigen Schülern noch einmal ein vorurteilfreies, gründliches experimentelles und litterarisches Studium der Kupferfrage vorzunehmen und ich hoffe bei der Section Interesse für eine kurze Darlegung der wichtigsten Resultate zu finden. Auf die Wiedergabe von Einzelheiten und eingehender Litteraturkritik und Litteraturcitirung muss ich natürlich hier bei der Knappheit der zugemessenen Zeit verzichten.

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* Eine Substanz nenne ich im Folgenden *gesundheitsschädlich*, wenn sie in den Dosen, in denen sie in den Körper gelangen kann, eine unverkennbare, wenn auch leichte und vorübergehende Störung der Gesundheit bedingt, *giftig*, wenn sie schwere Störungen oder den Tod verursacht. Man hat vielfach den Forschern, welche die Giftigkeit der Kupfersalze leugneten, die Ansicht zugeschrieben, auch ihre Schädlichkeit zu leugnen; so weit ist aber kaum einer gegangen.

I.

Da hier nur von der ökonomischen Bedeutung des Kupfers gesprochen werden soll, so ist vor Allem anzugeben, welche Kupfermengen durch den Haushalt überhaupt in den Körper gelangen können.

Wir brauchen bei dieser Ueberlegung den natürlichen nicht unbedeutenden Kupfergehalt zahlreicher Vegetabilien nicht mit in Rechnung zu ziehen, da derselbe hygienisch offenbar ganz bedeutungslos ist. Es interessirt uns nur der Ueberschuss über diese normale Menge, wie er auf zwei Wegen in die Nahrung kommen kann.

1. Durch absichtlichen Zusatz von Kupfersalzen:
   a. zu Gemüsen zwecks Grünfärbung (Reverdissage);
   b. zu Mehl, um seine Backfähigkeit zu erhöhen, das Aussehen des daraus gebackenen Brotes zu verbessern und seinen Wassergehalt zu vermehren.
2. Durch Nachlässigkeit:
   a. unpassende Verwendung *reiner* Kupfer- oder Messinggefässe bei der Speisebereitung, d. h. Stehenlassen saurer oder fetter Speisen in Metallgefässen nach dem Kochen;
   b. Verwendung ungereinigt stehen gelassener, grünspahnbeschmutzter Kupfergeräthe.

Es handelt sich um exacte Angaben, welche Mengen von Kupfer auf diesem Wege in den Körper gelangen können:

1. Durch absichtlichen Zusatz:

a. In Gemüseconserven sind gefunden in 1 Kilo:

(1) von Riche und Magnier de la Source:

in Erbsen	- - -	16	Milligramm Kupfer
in Gurken	- - -	18	„ „
in Bohnen	- - -	35–45	„ „

(2) von Gautier:

im Durchschnitt	etwa 60
im Maximum	125
im Minimum	16

In Deutschland fand soeben Mayrhofer etwa 25–35 mg. Kupfer im Durchschnitt in vegetabilischen Conserven.

Die höchsten Werte, die bisher gefunden wurden, sind:

184	Pariser Laboratorium, Erbsen.
180 u. 270	Chatin u. Personne, Erbsen.
200	Cronquist, Stockholm.

Wo Angaben vorhanden sind, heisst es meist, dass der Geschmacksinn diese Kupfermengen nicht entdeckte.

Um zu bestimmen, welche Kupfermengen sich in Gemüse hineinbringen lassen, ohne dass sich der Kupfergehalt dem Geschmacksinn verräth, habe ich absichtlich Gemüse mit Kupfer behandelt und ihren Gehalt analytisch festgestellt.

Erbsen mit 186 mg. im Kilo schmeckten noch gar nicht nach Kupfer.

„ 244 „ haben keinen Kupfergeschmack.

Erbsen mit 634 mg. im Kilo werden noch ohne Widerwillen gegessen, haben aber widerwärtigen anhaltenden Nachgeschmack.

Bohnen mit 740 mg. im Kilo schmecken abscheulich und sind ungeniessbar.

Es bestätigen und erweitern also diese Angaben die Versicherung Gallard's, dass er und andere Personen an Erbsen mit 180–270 mg. Kupfer im Liter nichts geschmeckt habe.

b. Im *Brot* sind schon gefunden bis 130 mg. pro Kilo, doch ist solches Brot, obwohl noch frei von Kupfergeschmack, schon durch seine grünliche Farbe auffällig.

Es sind übrigens etwa 12–15 mg. (= 50 mg. Kupfersulfat) nach Bruylants ein vollkommen hinreichender Zusatz von unverkennbarer und vorzüglicher Wirkung, wenn man genöthigt ist, schlechtes Mehl zu verbacken.

2. Durch Kochen oder Aufbewahren in Kupfergefässen:

a. Bouillon:

(1) Reissuppe, 24 Stunden in Messing stehend enthält nach Mair in 1 Liter 24 Milligramm Kupfer und schmeckt sehr schlecht, kaum geniessbar.

(2) Eigene Versuche:

α. In einer Messingpfanne wird 1 Pfund Fleisch mit 1 Liter Wasser und entsprechend Salz 1¾ Stunden gekocht, das Fleisch herausgebommen, die Brühe auf einen Liter aufgefüllt und nun in der Pfanne stehen gelassen. Nach 24 Stunden Geschmack unverändert, in 1000 cbcm. 18 Milligramm Kupfer. Nach 48 Stunden grünliche Farbe, Geschmack fast unmerklich verändert, in 1000 cbcm. 36·8 Milligramm Kupfer.

β. In einer 7 Tage absichtlich mit etwas Bouillonresten stehen gebliebenen sehr schmutzigen, grünspahnbedeckten Messingpfanne wird der Versuch wiederholt.

Nach 24 Stunden blassgrün, 40 Milligr. Kupfer,
Nach 48 Stunden deutlicher grün, 58 mg. Kupfer,
} Geschmack schwach, etwas Nachgeschmack.

Der Geschmack wird also etwa von 40 Milligramm im Liter Bouillon an unangenehm, wenn kein Grünzeug* zugesetzt wird.

b. Fett:

Es wurde in blanke Messing- und Kupferschalen von 100 und 75 cbcm. Inhalt 75 resp. 50 cbcm. ausgeschmolzenes, filtrirtes, kochsalzfreies Butterfett eingegossen. In den verschiedenen Versuchen wurde bald stark, bald schwach ranziges Fett verwendet, dasselbe bald 1 Stunde auf 120–180° in der Schale

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* Bei reichlichem Grünzeug- (Julienne-) Zusatz konnten wir noch Suppen herstellen, die mit 75 und 100 Milligramm im Liter erträglich schmeckten, mit 200 Milligramm aber schmeckte Suppe unerträglich, trotz Grünzeugzusatz. Wurde das Kupfer als Acetat zur Brühe gesetzt, solange das Fleisch noch mitkochte, so waren 200 Milligramm Kupfer mit Leichtigkeit in der Masse (Suppe + Fleisch + Gemüse) ohne auffallenden Geschmack unterzubringen.

erhitzt, bald nur heiss eingegossen und (24 bis 7 mal 24 Stunden) stehen gelassen. Von den 15 hieher gehörigen Versuchen sei nur erwähnt, dass 100 cbcm. stark ranziges Fett (Rancidität 9) in 14 Tagen 8·7 mg. Kupfer aufnahmen. Es war hier das Fett nur heiss eingegossen.

Aehnliche Mengen wurden durch einstündiges Erhitzen auf 160° und 24stündiges Stehenlassen erhalten.

Schliesslich wurde eine blanke Messingschale von 90 cbcm. Inhalt ½ mm. hoch mit Butter von der Rancidität 10 eingerieben und 24 Stunden im Zimmer stehen gelassen, das Fett färbte sich intensiv bläulich grün. Hierauf werden 50 cbcm. Butter von Rancidität 8 eingegossen und wieder 24 Stunden stehen gelassen. Untersuchung wie oben ergibt 5 mg. Kupfer, also in 100 cbcm., 10 Milligramm Kupfer.

c. Wein (kalt):

In Gläsern, die je 2 Liter sauren fränkischen Landwein enthielten, tauchten 600 Quadratcentimeter Kupfer- resp. Messingblech bald ganz unter, bald ragte ein Stück Blech über die Oberfläche empor. Es zeigte sich, dass bei herausragendem Blech mehr Kupfer in Lösung ging und dass aus Messingblech etwas mehr als aus Kupferblech aufgelöst wurde.

1 Liter Wein nahm beispielsweise aus hervorragendem Kupfer auf:

In 24 h. - - -	21 mg. Cu.
In 7 mal 24 h. - - -	56 „ „

Ueber den Geschmack kann ich noch folgende Angaben machen:

Wenn 1 Liter Wein (als Acetat) enthält:

Gehalt.	Eigenschaften.
50 mg. Kupfer - -	gut geniessbar.
100 „ „ - -	zeigt schwachen Nachgeschmack.
150 „ „ - -	kaum geniessbar, starker Nachgeschmack.
200 „ „ - -	ungeniessbar, leicht blaugrünliche Farbe.

d. Essig (kalt):

Versuchsverfahren wie bei Wein.

Ein Liter nahm auf:—

—	Herausragendes Messing.	Herausragendes Kupfer.
In 24 h. - - - - -	61 mg.	55 mg.
In 7 mal 24 h. - - - - -	195 „	155 „

Besondere noch nicht abgeschlossene Versuche zeigen, dass auch sauere Ragouts, Sauerkraut u. dergl. nur bescheidene, oft sogar nur sehr geringe Mengen aus Kupfergefässen aufnehmen.

II.

Fragen wir nun, gestützt auf die ermittelten Zahlen, welche Kupfermengen können im ungünstigsten Falle durch eine Mahlzeit in den Körper gelangen, ohne dass es den Sinnen zu sehr auffällt? Die grüne oder blaugrüne Farbe, vor allem aber der adstringirende Kupfergeschmack, werden ja vor allzugrossen Mengen warnen. Nehmen wir an, dass die Mahlzeit bei Licht oder schlechter Beleuchtung verzehrt werde, so dass die blaue Farbe der Speisen weniger bemerkt wird, so können wir nur durch den Geschmacksinn aufmerksam werden.

Im schlimmsten Fall könnte so etwa bei einem wenig empfindlichen Gaumen in einer starken Mahlzeit in den Körper gelangen:

In 300 ccm. Suppe - - - -	20 mg.
„ 1 Liter Wein, der in Kupfer stand -	50 „
„ 50 ccm. Essig, „ „ - -	10 „
„ 50 g. Fett, das zum Braten diente -	5 „
„ 200 g. stärkst gekupferten Erbsen -	50 „
„ 500 g. maximal kupferhaltigen Brotes -	60 „

Also im Maximum 195 mg. Doch wird natürlich ein solcher Fall nie vorkommen.

Das leuchtet aber sofort ein, dass viel leichter in einer aus kupferhaltigem Brot und Conserven bestehenden Mahlzeit hohe Kupferdosen in den Körper gelangen, als durch Suppe, Ragout u. drgl., selbst wenn sie in grünspahnbedeckten Kupfergeschirren hergestellt werden, wenn nur keine stark sauren Gemüse in Kupfer gekocht und erkaltet sind.

Wenn wir die Conserven und das Brot ausschliessen, wird überhaupt selten mehr als 30–50 mg., kaum jemals 100 mg. Kupfer bei einer Mahlzeit in den Körper gelangen können, in Conserven und Brot dagegen ziemlich leicht 100, ja bis 200 mg.

III.

Auf die Frage, von welcher Menge ab reine Kupferpräparate bei einmaligem Einnehmen wirken, antwortet die Pharmacologie, dass Dosen von 10–30 mg. Kupfer in hinreichender Verdünnung meist wirkungslos sind, dass etwa 50–100 mg. Kupfer Uebelichkeit, Brechreiz und in der Regel Brechen erzeugen.

Auch von grösseren Dosen bis etwa 200 mg. (d. h. etwa 0·8 g. Kupfersulfat), auf einmal genommen, findet sich nirgends eine andere beglaubigte Wirkung als Erbrechen angeführt, höchstens sind noch kolikartige Leibschmerzen und schmerzhafte Diarrhoen erwähnt.*

Zu therapeutischen Zwecken fanden oft sehr grosse Dosen Verwendung. Kinder nahmen z. B. bei Du Moulin in 5–6 Tagen $1\frac{1}{2}$–$2\frac{1}{2}$ g.

* Mischt man Hunden oder Katzen, die vorher nie Kupfer erhielten, unter die Nahrung auf einmal eine concentrirte Lösung von 1 g. Kupfersulfat = 250 mg. Kupfer, was nicht immer leicht eingenommen wird, so brechen auch diese Thiere blos und zeigen keine weiteren Symptome. Tötet man sie, so sind höchstens ganz minimale Anätzungen an der Magenschleimhaut (Röthungen und Epithelabstossungen) zu sehen. Und doch entspräche diese Dosis (50–100 mg. Kupfer pro Kilo) beim Menschen einer ganz gewaltigen Gabe.

Kupfersulfat, d. h. pro die c. 0·5 g. Kupfersulfat = 120 mg. Kupfer. Sie erbrachen oft nur die ersten Dosen und behielten das übrige bei sich. Ja in einzelnen Fällen verordneten Aerzte bis zu 1 g. Kupfersulfat = 250 mg. Kupfer an einem Tage. Niemals wurde irgend ein Schaden davon gesehen, selbst wenn nur wenig gebrochen wurde.

Die kleinste genau bekannte Dose eines reinen Kupfersalzes, von der ich eine ernstere Affection eines Erwachsenen in der Litteratur sichergestellt beschrieben finde, ist etwa 5 g. Kupfersulfat = 1,200 mg. Kupfer; einmal soll ein Kind an 1·2 g. Kupferchlorid, d. h. 560 mg. Kupfer gestorben sein, was bei der ätzenden Wirkung des diesmal ziemlich concentrirt genommenen Präparates wohl glaublich erscheint. Aber grade zur Einführung concentrirter Lösungen ist *im Haushalt* am wenigsten Gelegenheit gegeben. Dass es, wie es eine Idiosynkrasie gegen Erdbeeren, Krebse, Morphium, Ammoniakgas, schweflige Säure und viele andere Stoffe giebt, auch eine solche für Kupfer gelegentlich einmal geben kann, soll nicht geleugnet werden; solche Abnormitäten werden aber ohne jeden Einfluss auf unsere Reflexionen bleiben müssen. Crog hat Personen beobachtet, die angeblich 30 mg. Kupfersulfat = 8 mg. Kupfer auf einen ganzen Tag vertheilt nicht vertragen, ja, nach einer Angabe Blodig's hat Letzterer Intoxicationssymptome durch blosses Aetzen der Conjunctiva mit Kupfersulfatcrystallen beobachtet.

IV.

Die Vermuthung, dass einzelne Kupfersalze vielleicht schädlicher wirken als die anderen, entbehrt jedes Beweises. Es sind bisher von den einzelnen Autoren und mir selbst Acetat, Sulfat, Carbonat, Citrat, Succinat, Chlorid, von mir speciell vielfach Butyrat, Oleat, Lactat geprüft worden, ohne dass eine wesentliche Differenz der Wirkung bestände. Aber auch die verschiedenen Versuche der Autoren mit Kupferalbuminaten können nur die Ueberzeugung verstärken, dass eine specifische Wirkung irgend welcher Kupfersalze, wenn sie nicht an giftige Säuren gebunden sind, nicht besteht.

In einem Versuch, in dem ich selbst 132 Milligramm Kupfer in 200 Gramm selbst grüngefärbter Erbsen verzehrte, wurde bei dem Essen wenig unangenehmer Geschmack, aber etwa ½ Stunde anhaltender kupferiger Nachgeschmack bemerkt; nach dreistündiger abwechselnd schwerer und leichterer Nausea trat ein zweimaliges heftiges Erbrechen, dann aber vollkommenes Wohlbefinden ein, vier Stunden später wurde mit Appetit zu Abend gegessen.

V.

Die Litteratur enthält keinen einzigen Fall von akuten Vergiftungen durch kupferhaltiges Brot oder Conserven, obwohl, wie wir sahen, auf diesem Wege am Leichtesten grosse Kupfermengen eingeführt werden und sicherlich schon häufig eingeführt worden sind, namentlich solange die Controlle nicht streng und die Verwendung des Kupfers zu diesen Zwecken in manchen Ländern allgemein war.

Dagegen sind eine Menge Fälle gut oder schlecht beschrieben, in denen schwerste, ja tödtliche Erkrankungen eintraten, nachdem eine

Suppe, ein Ragout oder drgl. verzehrt war, das nachher als kupferhaltig erkannt wurde. Wenn überhaupt die Untersuchung auf Kupfer quantitativ ausgeführt wurde, so ergab sie in diesen Fällen niemals Zahlen, die es auch nur entfernt darthun, dass einer der Erkrankten auch nur 150–200 Milligramm verzehrt habe; gewöhnlich liess sich nur die Aufnahme von 20–50 Milligramm Kupfer wahrscheinlich machen.

Da sich weder viel Kupfer noch die Anwesenheit besonders giftiger Kupferverbindungen in den mit Kupfergeschirren bereiteten Speisen nachweisen lässt, so drängt sich dem Unbefangenen die Annahme auf, dass vielleicht neben den Kupferverbindungen andere Gifte vorhanden gewesen sein möchten.

Die Thatsache, dass in vielen der sogenannten Kupfervergiftungen nach Einführung kleiner Kupfermengen neben Brechdurchfällen die verschiedensten nervösen Störungen wie Kopfweh, Zittern, Manie, Scorbut, bei den Sectionen schwere geschwürige Magendarmentzündungen angegeben werden, spricht auch sehr gegen die Bedeutung des Kupfers.

VI.

Die ökonomischen "Kupfervergiftungen" sind meist durch Nahrungsmittel bedingt, die *längere Zeit* in Kupfer aufbewahrt waren; nehmen wir nun an, dass dabei gebildete Bacterienstoffwechselproducte die eigentliche Schädlichkeit darstellen, so erscheint die grosse Mehrzahl der "Kupfervergiftungen" in ganz anderem Licht. Jetzt ist ohne weiteres verständlich:

1. warum so wenig Kupfer zur schweren Vergiftung nöthig erscheint;
2. warum die stets sehr kupferarme Fleischbrühe, Ragouts u. dgl. so oft Kupfervergiftungen bedingen, dagegen stark kupferhaltige Conserven noch nie ernstere Erkrankung erzeugen;
3. warum die Krankheitsbilder so verschieden sind, oft von schweren nervösen Symptomen begleitet;
4. warum so häufig bei dunkeln Vergiftungsfällen ganz die Symptome der sogenannten "Kupfervergiftung" auftreten, ohne dass eine Spur Kupfer nachgewiesen werden konnte, so sehr man auch nach dieser bequemen Erklärung für die Störung gesucht hatte;
5. warum mit der zunehmenden Kenntniss von den Ptomaïnvergiftungen die Kupfervergiftungen in der Litteratur immer seltener werden.

Es soll damit nicht gesagt sein, dass nicht auch andere organische oder anorganische Gifte gelegentlich einer Kupfervergiftung vorgetäuscht haben.

Es möge mir gestattet sein, an einigen älteren und neueren Fällen meine Ansicht über die angeblich bewiesene Bedeutung der Kupfergeschirre zu zeigen.

Johann Peter Frank erzählt in seinem vorzüglichen "System einer vollständigen medizinischen Polizei, 1783," neben einigen anderen

Alarmgeschichten über die Giftigkeit des Kupfers im Eifer einen Fall, in dem die Väter des Oratoriums zu Angers alle nach dem Genuss eines Ragouts sehr schwer erkrankten, welches in einem völlig reinen *gut überzinnten kupfernen* Gefäss nur aufgewärmt worden war. Wer zweifelt hier an einer Fleischvergiftung?

Navier (1772) berichtet von schweren Vergiftungen an 7 Personen einer Familie durch einen Kuchen und Ragout und Suppe. Es soll hier ein kupferner Schaumlöffel, mit dem das zum Kuchen verwendete Butterschmalz abgeschäumt wurde und der auch zum Abschäumen der Suppe Anwendung fand, an dem Unglück schuld gewesen sein. Diese Erklärung ist einfach grundlos, die Möglichkeit einer nennenswerten Kupfereinführung ausgeschlossen,—eine Ptomaïnvergiftung durch das Fleisch, eine Barytvergiftung oder Mehlptomaïnvergiftung durch den Kuchen unendlich wahrscheinlicher.

Die berühmte oft citirte von Pleischl und Heller 1847 im Krankenhaus zu Wien beobachtete "Kupfermassenvergiftung" kann ich auch nicht auf Kupfer beziehen. Es erkrankten 130 Personen, von denen neun theils unter den Symptomen der Manie, theils des Scorbuts zu Grunde gingen! Die Ulcerationsprocesse im Darmkanal wären nur bei sehr grossen ätzenden Kupfermengen auf letzteres zu beziehen; so bildet die ganze Erkrankung das schönste Pendant zu den Fleischvergiftungen der neueren Zeit, wenn auch Heller etwas Kupfer in den Speiseresten und im Erbrochenen der Kranken fand.

Für die beiden neuesten von Mair beschriebenen tödtlichen Kupfervergiftungen (Friedreichs Blätter 1887) kann ich auch durchaus nicht den Beweis, dass das Kupfer die Todesursache darstelle, als geliefert ansehen. Beide Fälle sollen durch Verwendung von Kupfergeschirren zu erklären sein; der eine könnte ebensogut eine Ptomaïnvergiftung, der andere sehr interessante, bei dem 4 Personen in wenigen Stunden starben, eine Kohlenoxydvergiftung darstellen.

VII.

Lässt sich durch das Bisherige darthun, dass beim gesunden Erwachsenen schwere akute ökonomische Kupfervergiftungen kaum eintreten können, so mag gerne zugegeben werden, dass das Erbrechen, das auf die Einnahme grosser Dosen folgt, gelegentlich bei geschwächten Individuen, namentlich schwachen Greisen, zufällig eine schwere Störung der Herzfunction, Collaps u. dergl. auslösen kann. Hier hat das Kupfer aber keineswegs specifisch, sondern nur wie ein einfaches Brechmittel gewirkt.

VIII.

Es handelt sich nun noch um die Frage der chronischen Kupfervergiftung. Die Zeiten, in denen die übertriebenen kritiklosen Schilderungen von der Häufigkeit chronischer Kupfervergiftungen

namentlich bei Fabrikarbeitern geglaubt wurden, sind längst vorüber. Die Gastropathia cuprica febrilis, die Colica acruginis, die Kupferlähmung sind jetzt entweder als seltene Krankheiten erklärt—oder der Zusammenhang derselben mit dem Kupfer wird gar ganz geleugnet, und Blei, Zink, Cadmium, Kohlenoxyd und andere chemische eventuell auch physikalische Schädlichkeiten als wahre Krankheitsursache betrachtet.

Eigene Erfahrungen habe ich an Kupferarbeitern keine sammeln können, kann aber durch die Güte des ausgezeichneten Kenners der Gewerbekrankheiten, Medicinalrath Dr. Merkel in Nürnberg, mittheilen, dass derselbe trotz der grossen Bronceindustrie in Fürth, bei der die Arbeiter von Broncestaub ganz vergoldet und versilbert sind, *nie* eine Kupfervergiftung gesehen hat. Hirt's Erklärung der Kupferkolik als akute Kupfervergiftung bei unreinlichen Kupfer- (Grünspahn-) Arbeitern erscheint mir recht annehmbar, um einen Theil der Fälle, wo man mit der Annahme einer Vergiftung durch andere Metalle nicht auskommt, zu erklären. Für einige wenige in der Litteratur immer wieder abgedruckte Fälle : Kupfervergiftung bei einem Buchbinder durch Vergolden der Bücherrücken mit unächtem Gold, bei einem Manne durch ein in Kupfer gefasstes Gebiss, ist nur die Annahme einer besonderen ganz räthselhaften Idiosynkrasie möglich, wenn nicht auch hier irgend eine falsche Deutung vorliegt.

Von einer chronischen Vergiftung durch kupferhaltige Nahrungsmittel (Brot, Conserven) enthält die Litteratur keinen einzigen gut beobachteten Fall, dagegen ass Galippe experimenti causa 14 Monate mit seiner Familie blos in Kupfer zubereitete und häufig darin erkaltete Speisen ohne jeden Schaden.

Ich selbst habe, um mir über die älteren Erfahrungen von Toussaint, Du Moulin u. A., an Thieren und Menschen ein objektives Urteil zu bilden, langdauernde Fütterungsversuche mit meinen Schülern an 6 Kaninchen, 4 Katzen und 1 Hunde angestellt. Es wurden dabei, nachdem die Thiere sich in einigen Tagen an den Kupfergehalt der Nahrung durch kleine Dosen (10–30 mg. Kupfer) gewöhnt hatten, meist Dosen von 50, häufiger noch von 100 mg. Kupfer gefüttert und die Versuche 2–4, einmal 6 Monate fortgesetzt.

Es wurde Sulfat, Acetat, Chlorid, Oleat, Butyrat, Lactat ohne jeden Unterschied der Wirkung verwendet.

Die Salze wurden stets vollkommen mit der Nahrung gemischt und ihre Aufnahme controlliert. Abgesehen von gelegentlichem Erbrechen und bei der Section einigemal entdecktem Magenkatarrh waren die Thiere ganz wohl, speciell auch die Nieren gesund. Ein Theil der Thiere zeigte sogar beträchtliche Gewichtszunahme. Nervöse Symptome, Krämpfe, Lähmungen, Diarrhoen, Obstipationen wurden nie beobachtet. Dagegen wies die Analyse der Organe eine bedeutende Kupferresorption nach, die Lebern der Katzen enthielten durchschnittlich 12 mg. Kupfer, auch in den übrigen Organen war etwas mehr Kupfer als bei akuten Intoxicationen zu finden.

Trotz der Versuche von Toussaint und Galippe am Gesunden und so vieler interessanter Erfahrungen an lange Zeit mit hohen Kupferdosen behandelten scrophulösen und nervenkranken Personen, erschien es mir erwünscht auch am gesunden Menschen nochmals Erfahrungen zu sammeln.

Es nahmen daher 2 meiner Schüler nochmals täglich in Bier kleine Kupfermengen, der eine als Sulfat, der andere als Acetat:

Herr M	50 Tage	10 mg.	Cu =	39 mg.	Kupfersulfat
dann	30 „	20 „	=	78	„
Herr K	3 „	5 „	=	16 mg.	Kupferacetat
	10 „	10 „	=	32	„
	1 „	15 „	=	48	„
	19 „	20 „	=	64	„
	18 „	30 „	=	96	„

Beide Herren beobachteten nicht ein einziges mal die leiseste Störung an sich weder während des Einnehmens noch nachher. Ich wählte die Dosen absichtlich kleiner, als sie zu therapeutischen Zwecken genommen zu werden pflegten, da ich auch jede Magenbelästigung vermeiden wollte.

Soweit man nach 2- bis 3-monatlicher Versuchsdauer einen Schluss ziehen kann, muss ich mich unumwunden dahin aussprechen: Die Versuche am Menschen mit kleinen Kupferdosen sprechen auch bei uns absolut gegen die Möglichkeit einer chronischen Kupfervergiftung, durch die im Haushalt vorkommenden Mengen.

Es sei mir noch gestattet, aus einem schon recht umfangreichen und mühsam gewonnenen Zahlenmaterial hier noch einige theoretisch interessante Daten vorläufig mitzutheilen: Von mittleren Kupferdosen, die man einnehmen lässt, werden einige Procent resorbiert (von kleinen Dosen mehr, von grossen weniger); leichte Magenanätzung scheint ohne Bedeutung für die Resorptionsgrösse; die grösste Menge des offenbar vorwiegend aus dem Darme resorbierten Kupfers wird vorübergehend in der Leber deponirt, der Hauptausscheidungsweg für das Kupfer scheint beim Hunde die Leber, beim Kaninchen der Darm, beim Menschen die Niere.

Für den Menschen haben wir speciell durch zahlreiche sorgfältige Analysen dargethan, dass nach Einnehmen von 30 mg. Kupfer im Harn in 3 Tagen zusammen circa 4–5 mg. erscheinen, über die Ausscheidung durch Darm und Galle lässt sich beim Menschen natürlich nichts weiteres sagen.

IX.

Von diesen Erwägungen geleitet, ist eine directe Schädigung akuter oder chronischer Art von *den* Kupfermengen nicht zu befürchten, wie sie durch maassvolle und kunstgerechte Reverdissage, Brotbereitung mit Kupfer, und etwas sorglose Benützung kupferner Gegenstände im Haushalt in den Körper gelangen; dagegen können durch grob

nachlässig hergestellte Conserven oder Brot und absolut nachlässig behandelte Kupfergeschirre recht wohl Erbrechen, vielleicht auch einmal Brechdurchfall, aber kaum *mehr* entstehen.

Die Hygiene wünscht ein Verbot der Verwendung von Kupfer zur Färbung von Gemüseconserven, weil:

a. die Gefahr des Missbrauchs (des nachlässigen Zusatzes zu grosser d. h. schädlicher Mengen) vorliegt;

b. weder Haltbarkeit noch Geschmack der Conserven dadurch gewinnt;

c. kein Grund vorliegt die Conserven grüner zu färben als die frisch gekochten Gemüse.

Die Hygiene hat also ein Interesse daran, den nutzlosen Kupferzusatz zu Gemüsen überall zu verbieten; der Uebertreter dieser Vorschrift wird aber nur dann "wegen einer möglicherweise eintretenden "Beschädigung der menschlichen Gesundheit" zu bestrafen sein, wenn wirklich bedeutende Mengen Kupfer in die Gemüse eingeführt sind. Der Zusatz *kleiner* Mengen, etwa 20–30 mg. pro Kilo, wird nur aus nicht hygienischen Gründen, wenn man will "als scheinbare Verbesserung," als "Täuschung über die Qualität" u. dergl. zu bestrafen sein.

Der Zusatz von Kupfer zu Brot ist stets absolut zu verbieten, weil:

a. die Gefahr des nachlässigen Zusatzes zu grosser gesundheitsschädlicher Mengen vorliegt;

b. verdorbenes, unter Umständen schädliches, verdorbenes Mehl wieder backfähig wird;

c. ein vermehrter Wasserzusatz (6–7 %) möglich wird.

Kupfergeschirre sollen nicht zum Aufbewahren fetter, saurer oder gesalzener Speisen dienen.

Damit ist Alles geschehen, um auch die leichten Kupferschädigungen auszuschliessen.

Die gerichtliche Medicin hat die Pflicht, viel mehr als dies heute noch geschieht, bei angeblichen schweren Kupfervergiftungen durch Speisen quantitative Ermittelungen anzustellen, um darzuthun, ob denn wirklich allermindestens 200 Milligramm Kupfer von dem Vergifteten genossen sind. Lässt sich dieser Beweis nicht führen, so ist an eine Kupfervergiftung bei einem Erwachsenen nicht zu denken, vielmehr durch Anamnese und Analyse nach Ptomaïnen oder Toxalbuminen zu fahnden. Für eine tödtliche Kupfervergiftung am gesunden Erwachsenen sind nach unseren Kenntnissen mindestens 1200 mg. Kupfer nöthig.

DISCUSSION.

The President briefly recapitulated the chief points of Professor Lehmann's Paper in English, and pointed out the great value of the results therein described.

Mr. Goodfellow remarked that, having had occasion within the last three years to examine a large number of samples of English bread for adulterants, he was enabled to say that no case of adulteration with copper sulphate had come under his notice. He had, however, examined seven specimens of Dutch bread, and had found traces of copper sulphate in four cases.

Mr. Cassal said that copper had not been found in bread by British public analysts, so far as he was aware, since the passing of the "Sale of Food and Drugs Act, 1875." If it ever existed as an adulterant of bread, it must have been some time before the passing of that Act. There had recently been a conviction at Glasgow for selling tinned peas containing copper.

Dr. H. G. Colman asked Professor Lehmann whether he believed that tin, as well as copper, had not the great poisonous effect usually ascribed to it. Most of the cases of poisoning from tinned meats which had been ascribed to tin-poisoning really appeared to be due to ptomaines.

Dr. W. J. Russell, F.R.S., believed that the bad character of copper had been gained owing to the ease with which it is detected in small quantities in chemical analysis, and alluded to the curious fact that considerable quantities of copper were contained in the two red tail-feathers of the Touracon.

Professor Lehmann, in reply to Dr. Colman, stated that tin, when taken in small quantities for a length of time, had, undoubtedly, an ill effect upon the system, but believed that all the supposed acute cases of tin-poisoning were in reality caused by ptomaines.

The Action of Water on Lead.

BY

J. H. Garrett, M.D., D.P.H.

The subject of the action of water on lead has a special hygienic interest on account of its resulting in the contamination by lead of drinking-water.

In the Gulstonian Lectures, delivered in the early part of the present year before the Royal College of Physicians of London, Dr. Thomas Oliver has treated the subject of lead poisoning in an exhaustive manner, and to his treatise reference can be made for information upon the pathological effects likely to accrue from imbibition of this metal and its salts.

The chemical aspect of the question, which at present concerns us, has received the attention of several experimenters, but the want of agreement noticeable in their results has led to a confusion rather than to a settlement of the matter. I venture to suggest that this has been mainly due to the different ways in which the experiments have been conducted, and to the bias in favour of the acid, which is sometimes con-

tained in natural waters that act on lead, being in some way the cause of the action.

By the observations I have made upon the action of a great many waters, I am convinced, and cannot think there is room for doubt, that the primary action of water on lead is in every case a process of oxidation. Thus, the invariable result of putting lead into contact with water neutral or faintly alkaline in reaction, such as most distilled waters, is the production of a colourless crystalline oxyhydrate of lead that is almost insoluble in pure water. I have recently had under examination numerous samples of soft waters from the Devonshire rivers, &c., and have found that they act upon lead in a manner practically identical with the action of distilled water, and a similar effect may commonly be obtained from rain water. In each case solid oxyhydrate of lead is rapidly produced, and falls off the lead as it is formed, leaving a fresh surface to be acted upon. The air being admitted to the surface of the water, this action is continuous, lasting for weeks or months, or until the lead is buried in the deep layer of oxyhydrate produced.

With the action of these neutral or faintly alkaline waters, let us contrast the action of a decidedly acid water. Naturally acid waters are found in connexion with peat and otherwise, but the composition of the acid which these peat waters contain is at present unknown. When one of these acid waters is placed in contact with lead we get a clear solution of lead salt as an immediate result; but, doubtless, the lead is oxidized before being dissolved by the acid. The amount of acid present of course determines the amount of lead that can be dissolved. The action does not necessarily stop here, however, but the oxidation of the lead may continue beyond the point of saturation of the acid, and the extra oxide formed, or a part of it, combining with the neutral salt in solution forms an oxysalt. This oxysalt being less soluble than the neutral salt, less lead is now contained in solution; a portion of that at first dissolved now forming part of the deposit that lies upon the bottom of the vessel or upon the surface of the lead. When the acid in the water is very small in quantity the usual production of oxyhydrate of lead is only delayed for a short time. When a much more appreciable quantity of acid is contained in the water, the oxysalt which is thrown out of solution and deposited, or formed, upon the surface of the lead, tends to adhere firmly, and covering the lead protects it and thus brings the action to a termination. By a very careful neutralisation of the acid, the production of solid oxyhydrate may be made to commence immediately, just as it does in waters that are naturally neutral or nearly so. The oxyhydrate of lead itself gives the water an alkaline reaction, and the reaction of every water that is acting on lead is therefore destined to become alkaline ultimately, the only factor necessary for the continuous oxidation of the lead being a constant supply of oxygen.

Waters which are decidedly alkaline by reason of containing considerable quantities of a carbonate, such as calcium carbonate, including

those that deserve in any degree the title of hard waters, are prevented from acting on lead by the formation upon the surface of the metal of a closely fitting insoluble coat or film, which is presumably a basic carbonate of lead. The carbonic acid which ordinarily acts as a solvent to the carbonate of lime in hard waters, does not leave the carbonate of lime to dissolve carbonate of lead; but unusual waters may exist in which there is a very large excess of carbonic acid gas over that required to hold in solution the calcium carbonate, and the formation and solution of carbonate of lead may then be expected. Such a water must be included amongst the acid waters, and there is no acid water that so well exemplifies the effect of the continued oxidation at the surface of the lead, in causing the ultimate precipitation of the soluble lead salt at first formed, as distilled water into which carbonic acid gas has been passed. As will be seen in the following table, the solution becomes stronger until it contains lead in the proportion of 2·8 millegrammes per litre; but after 20 hours' further exposure the strength is reduced to ·14 millegrammes per litre.

TABLE showing the Amount of Lead dissolved by Distilled Water into which CO_2 has been passed.

Time exposed.	Lead in Solution.
3 hours	·94 millegrammes per litre.
10 „	2·8 „ „
30 „	·14 „ „

It has been stated by some authors that carbonic acid gas dissolves lead; by others, that it coats lead and prevents the action of water upon the metal. It does both; first the one, and then the other. For carbonate of lead is first dissolved by excess of CO_2; but this excess of CO_2 is presently neutralised by further production of oxide of lead. A great part of the lead at first dissolved is withdrawn from solution, and a basic carbonate is formed upon the surface of the lead which, protecting it from the water, causes cessation of action. The coat which carbonic acid gives to lead in this way is a soft white fur, quite different from the closely fitting film that is formed upon it when an alkaline carbonate is contained in the water. A fur similar in appearance, composed of basic salt, covers the lead as an ultimate result of the action of waters containing other acids, such as nitric, hydrochloric, or sulphuric, which in limited proportion have been purposely added to the water, or the acid naturally contained in peaty waters when it exists in them in sufficient quantity. The fact of a water containing certain neutral salts other than carbonate, such as sulphate, also leads to the formation of a similar fur upon the surface of the lead, a reaction between the oxyhydrate of lead and the sulphate of calcium, &c. evidently taking place. The presence of sulphate, chloride, &c. causes more lead to be retained in solution, and ammonia salts do the same thing in a particular degree, especially nitrate of ammonia. Sulphate diminishes the rate of production of oxyhydrate of lead, or puts an end to its production altogether by

clogging the surface of the lead with basic salt of slight solubility that does not fall off the surface of the metal as do the fine crystals of the oxyhydrate itself. The presence of chloride appears to increase the rate of oxidation of lead. Phosphate and silicate have some power in causing a closely fitting insoluble film to be formed on the surface of the metal which has influence in protecting it from further action of water; but the protective coat afforded by these salts does not form so quickly and perfectly as in the case with that formed by carbonate.

The rate of action of water on lead, whether the water be acid or faintly alkaline, is increased in a marked manner by increase of temperature, perhaps up to 70° C.; but above that temperature a comparatively slight and limited action takes place. In my experiments I have got the most marked results at about 50° C.

I am desirous of making it plainly understood that it is in waters that are nearly neutral in reaction that the production of lead salt occurs with greatest rapidity and continues with the least interruption; and lead may generally be found in such waters when they are conveyed through leaden pipes. It is not dissolved, but exists in a state of suspension. The minute crystals of oxyhydrate lend themselves very readily to suspension, and when suspended in a water may be easily overlooked, unless the water be critically examined in a good light. The lead when existing in water in this condition, has no doubt sometimes been taken to be dissolved. The practical effects are much the same as if it were dissolved; but it is well to make the distinction in considering the cause of the action of water on lead.

The action consisting primarily and chiefly in the oxidation of the metal, we are at the root of the matter when we begin to consider whence and how the oxygen is derived. What are the possible sources of oxygen? *a*. The free oxygen that is dissolved in the water. *b*. Oxygen that may be derived by decomposition of water, either by the lead itself displacing hydrogen, or by an electrolysis due to voltaic action resulting from the fact of common sheet and pipe lead being invariably alloyed with small quantities of other metals. *c*. Oxygen derived by reduction of the nitrates and nitrites, or other forms of oxidised nitrogenous matter, which occur in most waters to a greater or lesser extent.

If a water be obtained that has not the power of acting on lead, even though it contain no carbonate, &c. to obstruct the action (and such a water is occasionally met with) no amount of aëration will cause the action to start, or increase it where it only occurs in a slight degree. If a distilled water, which has been found to act on lead in the cold with rapid and continuous production of oxyhydrate, be placed in a platinum dish and boiled for five minutes, we may take it for granted that the whole of the free oxygen is dissipated. Now if without allowing the water to cease boiling we drop in pieces of clean lead, there should be no lead salt formed provided the action be wholly due to free oxygen. But a limited, yet decided quantity of lead salt is formed, giving the water

an opalescence and a flocculent deposit. This initial action cannot be due to free oxygen. But if it be thus proved that action can take place when the absence of free oxygen is assured, it is quite as easy to prove that a *continuous* oxidation of the lead cannot take place unless air be admitted to the surface of the water. A water which acts on lead with production of oxyhydrate being placed in an appropriate vessel along with pieces of clean lead, melted paraffin wax or oil is poured over the surface of the water, and the air is thus shut out. A check experiment is at the same time made with water and lead in the same proportions, but with the air freely admitted to the surface of the water. In the former, action occurs and proceeds for a time, and then abruptly comes to an end. In the latter, similar action occurs, and the two keep pace for a time equally with each other; but in this, the action continues after it has ceased in the other, so that at the end of a week the lead salt formed in it is vastly greater than that which has been formed in the one from which air is excluded. From this observation we are forced to the conclusion that whatever may be the initial cause of the action, the continuation of it beyond a certain point is certainly dependent upon absorption of oxygen from the air.

The fact of the action requiring for its continuance, but not for its commencement, a supply of air, proves of itself that the action is not due to a decomposition of water either by a simple displacement of hydrogen by lead, or by electric influence. Besides this, at common temperatures, the action of water on lead does not result in any evolution of hydrogen, and it would not be possible for decomposition of water to proceed for any length of time without hydrogen being evolved. In regard to the production of an electric current by reason of the impurity of the lead, samples of pure metal, that is, as pure as could be obtained by igniting either of several carefully prepared plumbic compounds in a porcelain crucible, were found to have an action upon water precisely similar to the commercial metal. Silver is the metal that is most likely to exist in lead in such quantity as to cause any effect of practical importance in the action of water upon it. The minute traces of copper and other metals that may occur can have little appreciable effect. I have made experiments into the effects upon the oxidation of lead of coupling different metals along with it before immersing it in the water. Strips of foil of the several metals, of equal surface, were taken, and strips of lead were coupled with similar strips of each of the other metals by merely hooking and bending their ends together, so that the two metals formed a ring, half of which was of lead and half of the other metal. A check experiment being made with one of the pieces of lead-foil alone, the amount of lead salt formed from the lead alone, could be compared with that formed by each couple. The lead used was a thick lead-foil, supplied by Messrs. Hopkin and Williams, of Hatton Garden, which was stated to be pure lead. Some of the other metals were supplied by the same firm in the form of thick foil. The following results were obtained. The experiments were performed simultaneously, and equal measures of water were used. Temperature averaged about 17° C.

Experiment I.—The water used was distilled water with a slightly alkaline reaction. The metals were in the water 12 hours, being wholly immersed.

Metals employed.	Relative Amount of Lead converted into Lead-salt.
Lead alone	100
Lead and silver	120
Lead and copper	108
Lead and iron	100
Lead and aluminium	16
Lead and tin	14
Lead and zinc	6

Thus the silver and copper coupled with lead caused a slight increase of action on the lead in this alkaline water, whilst aluminium, tin, and especially zinc, caused a marked diminution. The silver and copper did not themselves appear to be affected, but some oxidation of the iron and other metals took place.

Experiment II.—The water used was distilled water, made very faintly acid with acetic acid. The metals were in the water three hours, wholly immersed as before.

Metals employed.	Relative Amount of Lead converted into Lead-salt.
Lead alone	100
Lead and copper	150
Lead and silver	133
Lead and iron	7
Lead and zinc	5
Lead and aluminium	0
Lead and tin	0

Coupling with aluminium and tin wholly prevented the oxidation of lead in this water whilst coupling with copper and silver again increased it. The silver and copper themselves appeared unaffected, but the other metals could be detected in the respective waters.

Experiment III.—The water used was as in last experiment, but was made more strongly acid with acetic acid. It contained, in fact, about ½ per cent. strong acetic acid. The metals were immersed in the water 12 hours.

Metals employed.	Relative Amount of Lead converted into Lead-salt.
Lead alone	100
Lead and aluminium	7
Lead and tin	7

Experiment IV.—The water was a peaty water from Dartmoor, with a naturally acid reaction. The metals were immersed in the water three hours.

Metals employed.	Relative Amount of Lead converted into Lead-salt.
Lead alone	100
Lead and silver	300
Lead and copper	150
Lead and tin	70
Lead and zinc	70

With this water the zinc and tin did not appear to prevent action on lead in such a marked way as in previous experiments. The action was, however, increased to a greater extent by copper and silver.

It is a rare thing to meet with a water that is absolutely nitrate free; and as lead reduces nitrate at common temperature when contained in solution in a water, however minute a proportion be present, we have here an undeniable source of oxygen. Every nearly neutral water that acts on lead with production of crystals of oxyhydrate, and every naturally acid water that acts on lead with solution of the oxide, gives evidence of containing nitrite after the action has taken place. As the water did not contain nitrite in the first place, or if it contained nitrite the quantity is now increased, we are right in assuming that it has been produced by reduction of nitrate by the lead. In the hundreds of experiments that I have made upon the action of water on lead, in no case where the ordinary action has occurred have I failed to obtain ample proof of the presence of nitrite after the action. But although lead reduces nitrate to nitrite (and when air is excluded probably to hyponitrite) it never reduces it entirely to ammonia at common temperature. The reduction apparently does not take place with sufficient rapidity for this to happen; and unless water be decomposed, there is no hydrogen to form ammonia with the nitrogen of the nitrate. When there is free admission of air the nitrite is reoxidised by the oxygen of the air as fast as it is reduced by the lead.

The main action of water on lead is therefore due to the presence in the water of a nitrate (or some partially oxidised organic nitrogenous compound which admits of being reduced by the lead and reoxidised by the air giving the reaction of nitrite when reduced). The continuation of action observed to take place in a nearly neutral water, where oxyhydrate of lead is produced for weeks together, is due to nitrite acting as an oxygen carrier between the air and the lead. The rate of action is increased when copper, silver, and other metals are in contact with the lead beneath the water. The rate is diminished when zinc, tin, and other metals are similarly in contact with it, these metals suffering oxidation in preference to the lead.

DISCUSSION.

Dr. Rideal asked whether the reduction of nitrate to nitrite took place in the experiments cited by Dr. Garrett, only when a "couple" of two metals was employed; and if the reduction was continued to ammonia; as with a copper-zinc couple the presence of nitrite, and therefore of an oxygen carrier, would be prevented ?

Mr. W. R. Maguire (Dublin) said that in Dublin the public water supply from the Vartry River is a very pure one, resembling the Glasgow water from Loch Katrine. Fifteen years ago it was discovered that lead pipes and cisterns were attacked by this water, and the Corporation, in order to prevent lead poisoning, ordered that all lead pipes for water should contain 3 per cent. of tin. This had been carried out for 15 years without any case of lead poisoning attracting attention. Sir Charles Cameron found that small carp placed in the lead tanks showed signs of paralysis which so cramped their bodies that it caused them to miss their food as they darted at it. In tanks made of lead alloyed with 3 per cent. of tin this did not occur. Mr. Maguire inquired whether this alloy would give absolute security against lead poisoning. Small iron pipes could not be used to convey Vartry water, as the pipes were choked within a few months.

Dr. Russell mentioned a case in which a very pure water had dissolved a large amount of zinc from the containing tank.

What is the Importance of Magnesia in Drinking Water ?

BY

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It must be confessed that in spite of the enormous amount of attention which has for years been devoted to the chemical analysis of drinking water, we are still lamentably ignorant of the precise hygienic importance of the mineral constituents which analysis reveals. Indeed the diversity of opinion regarding these mineral substances is far greater than concerning the more obscure and less easily handled organic matters of drinking-water. Thus some authorities actually prefer waters containing a very considerable proportion of mineral matters, others object to such waters, and others again regard the matter with complete indifference. Phosphatic calculi, goitre, and cretinism have been by some referred to waters containing lime and magnesia salts, whilst others have adduced evidence that such disorders are wholly unconnected with hard water. This question of the relative fitness of hard and soft water for drinking purposes was submitted to

investigation by the Rivers Pollution Commission of 1868, who, after devoting no less than 16 pages to a critical review of the evidence before them, leave the matter in the supremely unsatisfactory condition indicated by the following words:—

> "We are, therefore, of opinion that whilst waters of excessive hardness may be productive of calculous and perhaps other diseases, soft and hard waters, if equally free from deleterious organic substances, are equally wholesome."

The said Commissioners are, however, entirely silent on the subject of magnesia; indeed amongst the innumerable analyses of potable water which occur in their Sixth Report there is, I believe, only one in which the magnesia is recorded at all. This is in the case of the water supplied from a deep well in the magnesian limestone to Sunderland, which is said to contain 3·96 parts of magnesia (MgO) per 100,000.

Within recent years there has however, arisen in certain quarters in this country a belief that magnesia when present in more than a very limited quantity is objectionable, and I am acquainted with at least one case in which an otherwise unimpeachable water was discarded in consequence of its containing a few grains of magnesia per gallon.

This view is the more open to question in consequence of the very limited information which is available concerning the proportions of magnesia which are commonly met with in British potable waters. The determination of magnesia is one of the most laborious which occur in water examination, and is consequently but rarely undertaken by water analysts; from time to time, however, I have had occasion to determine the magnesia in waters which have been submitted to me, and I think that it may not be without interest to place on record some of the results which I have obtained more especially on this occasion, so that the proportions met with in British waters may be compared with those found on the Continent where the magnesian formations are much more largely represented.

In the accompanying table, pp. 84 and 85, I have recorded the results of analysis of a number of typical samples, which serve to illustrate the proportions of magnesia found in the supplies obtained from some of the more important water-bearing strata of great Britain.

These analytical results show that the calcareous waters derived from the chalk contain only a very small proportion of magnesia, and that even in the highly saline waters obtained from the chalk below the London Clay the amount is also very moderate, only distinctly greater than in the case of the normal chalk waters.

The proportion of magnesia, again, is considerably greater in the water from the lias, as represented by the wells at Wellingboro', whilst the largest proportions were found in waters from the magnesian limestone and new red sandstone.

[ANALYTICAL TABLE.]

RESULTS OF ANALYSIS EXPRESSED IN PARTS PER 100,000.

Description - (I.).	Total solid Matters.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total Combined Nitrogen.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	Remarks.
Spring water from Newark-on-Trent, used for brewing purposes - (II.)	257·05	·046	·013	0	·465	·478	2·9	17·2	162·8	180·0	
	Fe_2O_3 and Al_2O_3		CaO	**MgO**	Na_2O	SO_3	N_2O_5	SiO_2	—	—	
	·14		82·89	**14·74**	4·68	131·51	1·79	·98	—	—	
Pontefract water supply from Magnesian limestone. (I.)	88·84	·035	·010	0	3·315	3·325	5·9	16·6	37·2	53·8	Total **MgO = 9·23.**
Well in bunter beds of new red sandstone at Sandiacre, Derbyshire. (I.)	45·04	·097	·037	·021	·094	·148	2·0	19·5	18·7	38·2	Total **MgO = 7·05.** Total CaO = 10·78.
Spring at Matlock Bath, Derbyshire. (I.)	47·84	·021	·002	0	·030	·032	4·1	18·8	15·3	34·1	Total **MgO = 4·08.** Total CaO = 11·37.
Bore-hole in alluvium near River Derwent, Matlock Bath. (I.)	24·44	·117	·048	·020	0	·064	·9	9·0	8·2	17·2	Total **MgO = 2·53.** Total CaO = 5·60.
Boring in new red sandstone at Gainsborough, Lincolnshire. (I.)	49·97	·028	·008	0	0	·008	2·0	16·8	18·6	35·4	
(II.)	·19		11·94	**5·97**	2·84	16·62	0	·94	—	—	
Waters from Malvern:											Total:—
No. 1. - - (I.)	27·48	·092	·024	0	·668	·692	1·9	11·6	9·6	21·2	**Magnesia = 4·09.**
No. 2. - - (I.)	8·52	·045	·016	0	·354	·370	1·2	0	4·3	4·3	Ditto = ·75.
No. 3. - - (I.)	12·56	·033	·014	0	·277	·291	1·5	2·9	5·0	7·9	Ditto = **16·4.**

[ANALYTICAL TABLE—*continued.*]

Description - (I.).	Total solid Matters.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total Combined Nitrogen.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.	Remarks.
Wells at Wellingboro' (I.)	58·20	·036	·017	·004	0	·020	2·2	30·3	16·2	46·5	
before softening - (II.)	Fe_2O_3 and Al_2O_3		CaO	**MgO**	Na_2O	SO_3	N_2O_3	SiO_2	—	—	
	·35		21·97	**4·05**	2·31	11·30	0	1·01	—	—	
Ditto after softening (I.)	26 30	·035	·014	·004	0	·017	2·2	1·1	14·9	16·0	
with lime - (II.)	·02		6·42	**2·16**	2·24	12·03	0	·63	—	—	
Well in chalk, Southampton, (I.)	31·69	·024	·012	·005	·365	·381	1·6	23·0	2·7	25·7	
before softening - - (II.)	·14		14·53	**·25**	1·21	·39	1·41	1·02	—	—	
Ditto after softening (I.)	14·07	·021	·013	·004	·381	·397	1·6	5·6	3·0	8·6	
with lime (II.)	·11		4·42	**·28**	1·12	·45	1·47	·94	—	—	Total **MgO**= ·92.
New River Company's (I.) water, London, before softening.	32·08	·150	·018	0	·308	·326	2·1	19·1	3·6	22·7	Total CaO=12·35.
Ditto after softening (I.) with lime.	13·48	·103	·017	0	·329	·346	2·1	1·9	3·4	5·3	Total **MgO**= ·80. Total CaO=2·14.
Well in chalk below London (I.)	59·29	·036	·013	·010	0	·021	8·3	10·0	0	10·0	Alkalinity (calculated
clay, London - - (II.)	·20		3·20	**1·97**	24·85	11·41	0	1·25	—	—	as Na_2O) = 8·69.
Well in chalk below London (I.)	58·76	·111	·017	·050	0	·058	16·7	19·8	8·0	27·8	
clay, Victoria Dock, (II.)	·22		12·57	**2·82**	13·13	3·96	0	1·44	K_2O=	·93	
London, before softening											
Ditto after softening (I.)	44·20	·084	·016	·060	0	·065	17·3	2·4	6·0	8·4	
with lime and caustic (II.)	·14		5·96	**·57**	15·76	4·01	0	·69	K_2O=	1·06	
soda - -											
Deep well in new red sand- (I.)	56·40	·099	·029	·004	0	·032	3·6	29·4	11·8	41·2	
stone at St. Helens - (II.)	·15		15·76	**6·31**	5·82	7·33	0	·97	K_2O=	·33	
Ditto after softening (I.)	—	—	—	—	—	—	—	—	—	15·7	
with lime - - (II.)	—	—	4·25	**5·41**	—	—	—	—	—	—	

It will be further seen that in all cases in which the proportion of magnesia is at all considerable (say, upwards of four parts), the permanent hardness is high (10 parts per 100,000 or upwards), whilst in none of the cases quoted is the permanent hardness above 10 without the magnesia being above four parts; in fact, in waters with low permanent hardness there is little chance of finding much magnesia, and *vice versâ*. Applying this rule, it will be found that in all probability an immense number of waters in common use must contain from four to six parts of magnesia per 100,000, a proportion which by some authorities is regarded as objectionable. Thus, of 28 samples of deep-well water from the new red sandstone analysed by the Rivers Pollution Commission, no less than 16 or more than 50 per cent. contained upwards of 10 parts of permanent hardness. Again, of 15 spring waters from the new red sandstone, seven exhibited upwards of 10 parts of permanent hardness. On the other hand, of 66 deep-well waters from the chalk, only five or 7·5 per cent. had upwards of 10 parts of permanent hardness; and of 28 spring waters from the chalk there was not one in which the permanent hardness amounted to 10 parts per 100,000.

If this investigation be extended to shallow wells, it will be found that the number of probably magnesian waters becomes enormously greater. Thus, of 87 samples of shallow-well water from the new red sandstone, no less than 84, or 96·5 per cent. had their permanent hardness in excess, and generally largely in excess, of 10 parts per 100,000; and again, of 33 samples of shallow-well water from the chalk, 27 exceeded the 10 parts of permanent hardness. Thus, without at all forcing the rule as to the relationship between permanent hardness and magnesia, it is obvious that waters containing from four to six parts of magnesia must be of very common occurrence indeed, and that a very large portion of our population must be supplied with them. Until, therefore, a far more searching inquiry than hitherto has been made into the alleged effect of such waters upon health, it appears to me highly undesirable that any importance should be attributed to such proportions of magnesia in drinking water which are otherwise of unimpeachable purity.

In conclusion, I would call attention to the effect of Clark's process on magnesian waters, which is recorded in several cases in the table. As a general rule, the proportion of magnesia removed by the treatment with lime is small, much smaller than that of the lime removed, but it is particularly worthy of notice that in the case where caustic soda was used in conjunction with lime, as is now frequently done in the softening of water for industrial purposes, the proportion of magnesia removed was greater than that of the lime.

As the recorded determinations of magnesia in British waters are comparatively scarce, I have thought it desirable to append the pro portions of lime and magnesia in a series of 50 brewery-waters which I have examined from all parts of the country, although in only a few instances am I able to assign the precise source of the samples.

BREWERY WATERS.

PARTS PER 100,000.

	Lime combined as Carbonate.	Total Lime.	Total Magnesia.
No. 1	11·96	18·21	·31
„ 2	7·49	7·74	3·90
„ 3	14·37	17·21	·20
„ 4	1·04	10·69	9·99
„ 5	13·91	20·67	·81
„ 6	3·36	6·26	2·24
„ 7	12·31	15·16	4·36
„ 8	3·24	6·34	1·34
„ 9	12·89	15·44	·76
„ 10	0	25·94	9·01
„ 11	16·27	20·46	1·81
„ 12	12·81	16·47	1·87
„ 13 (from Chapel-en-le-Frith, Derbyshire.)	0	1·04	·57
„ 14 (from Brighton)	14·06	20·87	1·11
„ 15 (Chalk below London clay)	2·81	2·81	1·33
„ 16 (from Cosham, Hants)	17·41	23·46	2·84
„ 17 (from Brighton)	10·30	13·69	·41
„ 18 „ „	11·51	16·39	·61
„ 19 (from Wrexham)	16·99	21·14	2·77
„ 20	6·40	10·74	·89
„ 21	10·37	10·69	6·21
„ 22	5·54	5·54	1·74
„ 23	9·53	11·13	·54
„ 24	13·11	15·67	·19
„ 25	2·84	3·37	1·40
„ 26	14·91	19·94	5·01
„ 27	5·91	7·16	1·07
„ 28 (from Reading)	15·90	25·57	1·21
„ 29	7·11	14·57	5·50
„ 30	20·26	23·04	8·81
„ 31	8·16	8·16	2·57
„ 32	14·51	17·00	7·36
„ 33 (from Cardiff)	5·04	14·86	3·91
„ 34	19·34	28·89	2·14
„ 35 (from Louth)	11·60	13·36	1·16
„ 36 (from Taunton)	9·79	10·16	1·27
„ 37	9·91	9·94	4·14
„ 38	9·36	11·87	·56
„ 39	13·94	15·21	·39
„ 40	·34	3·73	1·61
„ 41	17·64	32·56	5·99
„ 42	7·16	51·66	27·10
„ 43	12·71	46·60	20·57
„ 44	10·74	19·10	·60
„ 45	10·74	12·29	1·19
„ 46 (from Hertford)	12·61	14·37	·76
„ 47	·29	4·96	2·59
„ 48	10·04	11·00	3·03
„ 49	3·29	3·39	3·30
„ 50 (Chalk below London clay)	—	2·61	1·46

Average Magnesia = 3·41 parts per 100,000.

DISCUSSION.

Sir C. Cameron stated that the Dublin pipe-water was soft, containing only two grains of mineral matter per gallon. He found that soft lead pipes were sensibly affected by the water, and that small fish placed in tanks became affected or paralyzed. The waters in a large part of Ireland were hard waters, and contained magnesium as carbonate sulphate, and chloride. In many cases he had found from 3 to 10 grains of magnesium salts per gallon. The rock locally called calp, a limestone with large admixtures of aluminium silicates, silica, oxide of iron and iron pyrites, generally contained magnesia, often in large quantities. The Dublin well-waters were very rich in magnesium salts. He was not aware of any injurious influences upon health produced by these waters.

Dr. S. Barwise (Blackburn) stated that tinned lead pipes were quite satisfactory for soft peaty waters. The Blackburn water was very similar to the Dublin water; it acted on lead; but, owing to the Blackburn authority carefully insisting upon all lead pipes being lined with tin, they had no cases of lead poisoning.

Dr. T. M. Drown (Boston, U.S.A.) gave an account of the Massachussetts State Board of Health's investigations into the natural waters of the State, and described the establishment of isochlors or lines of equal chlorine-contents of the waters throughout the State.

Sir C. Cameron stated that in the soft waters in Ireland there was a relevancy between the amount of chlorine and pollution, but in the hard waters there was no such relevancy. Waters containing only 0·002 parts of albuminoid ammonia and 0·001 part of saline ammonia per 100,000 parts contained from 5 to 30 parts of chlorine per gallon.

The Importance of Periodic Analysis of the Air Breathed in Towns and Cities.

BY

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Good food, good water, and good air are the three necessary elements which conduce to and preserve the health of living units. All sound and healthy sanitation for the preservation of public health is based on principles which vouchsafe and safeguard the purity and wholesomeness of the supply of these three vital elements. In the words of Dr. Guy: "Public Hygiene has to do with persons of every "rank of both sexes and of every age. It takes cognizance of the places "and houses in which they live, of their occupation and modes of life, "of the food they eat, the water they drink, and the air they breathe." Man is able for himself to reject any article of food which is injurious to his health, yet in all large towns and cities it is regarded as a canon of sanitation to provide against unwholesome articles of food getting into the general food-supply; and to do this effectually sanitation has called in the aid of legislation, and rightly so. The provision of a pure

water-supply in towns and cities is everywhere acknowledged as a great sanitary duty, and, after a pure water-supply is provided, to maintain it in a state of purity is regarded as a sanitary obligation. It is rigorously insisted, and justly so, that no impurity shall be permitted to have access to such water, because the fouling of drinking water is often followed by fatal diseases. All the consideration which sanitation bestows on the water of towns and cities is no less required for the town and city air. It will not be disputed that of the three important elements for the preservation of health and life air is the most important one, and naturally so, considering the power for evil it possesses when in a state of impurity. The mortality produced by using noxious articles of food is trivial as compared with the deaths from diseases due to the drinking of impure water; and the mortality on the score of drinking impure water is considerably less—at least ten times less—than the mortality due to the breathing of impure air. The infant requires no water, but pure air, and more of it than the adult, inasmuch as respiration is most active in infantile life. Zymotic diseases, which destroy so much infantile life, are due in a considerable measure to impurities in the atmosphere.

If, then, the air we breathe, compared with the water we drink, has such a powerful influence, and that to such an extraordinary extent, for good or for evil, on the health and life of the population according as it is pure or impure, the preserving of the purity of the atmosphere, and the *preventing* its fouling, even with the help of legislation, has certainly the strongest claims on the sanitary duties and obligations of civilized towns and cities. And we should, therefore, expect to find in all well-supervised towns that the condition of the air was as closely and constantly watched as the condition of the water. Instead of this, what do we find? Carefully prepared periodic chemical examinations of the water-supply are made, and the results are made public. The people know the quality of the water provided for them. From time to time the health officer on the strength of his analyses recommends special measures for purifying the water before use. But there is no such periodic examination made of the atmosphere, and not one person in 10,000 knows anything of the condition of the air he breathes. The municipalities provide, at considerable expense, a water-supply of as pure a quality as can be obtained, and they take measures to maintain its purity. A pure air-supply is a provision of nature, and nature does try to maintain its purity. As soon, however, as population increases and a large number of dwellings are put up within limited areas, as occurs in towns and cities, the atmosphere necessarily gets vitiated to a certain extent; and the conditions of town and city life are inseparable from a somewhat polluted atmosphere. The expired air of human beings and animals is one constant source of pollution of nature's pure air. The dry sewage or garbage of cities, which is always accumulating as fast as it is carted away, is another source of pollution, and the decomposition of liquid sewage, whether in drains, sewers, or cesspits, is a third source of pollution. All these sources of pollution of town and

city air are ever active, and more so by night than by day, more active in warm than in cold climates. The oxygenation in plant life and the perpetual motion of the atmosphere itself are the powerful means nature has at her command for preserving the purity of its air supply.

But are they enough to cope with the constant sources of pollution in towns and cities? Does not experience teach us that the efforts of man to vitiate the atmosphere are always, and especially in such places as towns and cities, able to overcome the efforts of nature to keep up the purity of her air-supply? It is an everyday experience that wherever large numbers of people are crowded together, in theatres, public halls, workshops, mills, and other similar places, and where the ventilation of the buildings is defective, the proportion of impure constituents increases, and the atmosphere becomes distinctly vitiated and unsuited to the preservation of health. This is the way in which the atmosphere of towns and cities is poisoned, and the tenants of these houses made ill. The deadly effects of atmospheric blood-poisoning were most unmistakably seen in the unfortunate victims of the Black Hole of Calcutta, and in the prisoners after the battle of Austerlitz. And the experiments of the late Dr. Angus Smith have familiarised sanitary officers with the effects of vitiated air in human dwellings and in public halls.

But experience has abundantly shown that the general atmosphere of towns and cities as observed in the streets, in open places, and in gardens is always in a more or less impure state. And indeed, certain towns and cities have such characteristic smelling atmospheres that their names could be pronounced by the sense of smell alone. The odours of Bombay are peculiar to itself, and travellers smell Bombay a long way off. But the inhabitants themselves get so used to their own town odours that they, in time, do not perceive them. The natives, although they daily indulge in ablutions before every meal to keep their persons clean—and cleanliness is health—little think of the pollution of the air they breathe, often a fatal pollution to which they undoubtedly contribute through indifference, or ignorance, or both. The degree of impurity in the air which is inseparable from the conditions of town and city life is easily exceeded, and whenever impurities in the atmosphere exceed ordinary limits rapidly and to an unusually high degree, their poisonous effects at once manifest themselves. Fevers and throat affections and cases of blood-poisoning multiply in the city, especially in the hot months, when the sewers are most active in polluting the house and town atmosphere; then it is, also, that zymotic diseases increase vastly and provoke a great mortality, all of which might be prevented if the atmospheric conditions of the towns were regularly investigated, for means might be taken before the impurities have gained access to the atmosphere to such a dangerous extent. These rapidly occurring and often fatal effects of the fouling of the town and city air, no doubt, arrest attention, for they cause sudden and striking rises in the mortality. But there is a more insidious and slow process of poisoning which the population at large undergoes, and the

extent of its deadly influence is far in excess of that of the rapid process. A plentiful supply of fresh and wholesome air is the chief food of the blood. A falling off in its food-supply either in quality or quantity, or in both, is necessarily followed by poverty of blood which ends in general deterioration of physique. Not only does the blood suffer thus, but so also do the lungs, through which the air has access to the blood. When a healthy plant from the open garden is removed to a dark and dingy place with a foul atmosphere, the freshness and colour of its leaves—the lungs by which the plant breathes—decline, and signs of fading life gradually appear which ultimately overtake the whole plant itself. Is it to be wondered at that in the reaction between human lungs and the atmosphere impure air exercises similar deleterious effects? Tuberculosis derives its chief power from foul air. But short of true tubercular disease, there is a low form of lung breaking-down, a mild form of chronic phthisis which one meets with 'extensively in practice. Evidences of this form of lung mischief are to be found in patients who are admitted into the hospitals for other complaints. They are to be very generally noticed amongst people who have no idea of ventilation or of the wholesomeness or otherwise of the air they breathe, such as the occupants of chawl-rooms (which may have no windows, or, if there be any, they are generally shut); amongst people whose dwellings are apparently like mansions, but who occupy rooms therein to which one cannot see his way without candle-light even at mid-day; and in the occupants of lofty dwellings which have their atmosphere constantly fouled by the emanations from the godowns and animal-sheds below, and by the foul gas escaping from the decomposing garbage in the gullies, or by the sewer gas which keeps up a constant current through holes and escapes in the sullage pipes specially provided for it by the genius of the plumber. Indeed, the plumber has more to answer for in endangering public health and life than the jerry builder who jeopardises the lives of a few individuals by his fragile structures. The incompetent plumber is certainly the arch offender. He undermines general public health, and that in an insidious and unwary manner. It is a matter of congratulation that a special meeting of the Congress has resolved to urge upon the authorities the necessity of registration of plumbers, thereby eliminating the most serious, and yet the most preventible, element of danger to public health, by legally exacting from them a standard of education and training which would naturally carry with it a knowledge of the responsibility of their vocation and of their duty to the public at large. These little details have been gone into only to show the extent and gravity of the danger to public health from the undue fouling of town and city air, and all from preventible causes. Great and grave as the mischief is that is wrought by this fouling of Nature's pure air, the remedy is most simple and by no means difficult to apply, and to apply successfully. But to apply the remedy successfully, the right character and source of pollution must be traced; and neither the character nor the source of pollution can be traced unless systematic tests are applied regularly. And this cannot be done unless systematic air analyses are regularly and periodically made.

It will now be apparent that a regular examination of the air in towns and cities is as necessary, for the purposes of preserving public health, as the examination of the water-supply; and, indeed, more necessary. It is strange that no regular system of examination of the air of towns and cities has as yet found a place in sanitary police. Air analysis is undertaken in individual cases here and there for certain purposes. But the object of this paper is to point out that the work should be undertaken systematically in all towns and cities; and that the examination should include the air condition, not only of public halls, workshops, and kindred places, but of private dwellings, gulleys between houses, lanes, streets, parks, playgrounds, and places of all kinds temporarily or permanently occupied by human beings and animals. Much sanitary advantage would result if air analysis as now discussed were given its regular place in the reports of the health officer. It may be mentioned that, by resorting to air analysis, the atmospheric conditions of the public hospitals of Great Britain have been permanently improved. Exactly the same amount of improvement could be effected in towns and cities by applying similar tests to the whole of the populated areas. Fortunately, it happens that the sanitary duty now insisted on may be carried out without involving any but a small financial expenditure, while the chemical qualifications required to do the work are by no means great. In Indian towns and cities the subject of air analysis is almost unknown. In Bombay the health officer is the water analyst, but an air analyst has no existence. It is in India that this system would prove a very decided blessing, and for two special reasons, (1) because it is there that organic and vegetable pollution largely prevails, and decomposition of impurities takes place with great rapidity in the face of a high temperature, (2) because liquid sewage is a dangerous difficulty in that country, much more dangerous than in England.

DISCUSSION.

Professor Odling stated that the analysis of air for sanitary purposes was not new, and pointed out its value in regard to the incidence of disease. He considered that such an investigation as that proposed by the author to be carried out in India would be most important.

Sir C. Cameron said that the biological examination of air was of even more importance than the chemical. As a member of the Army Sanitary Committee, and a Special Commissioner from the War Office, he investigated the causes of the excessive amount of typhus fever in the Royal Barracks, Dublin. He found that the number of micro-organisms falling per minute per square foot in a well-known unhealthy part of the barracks greatly exceeded the number falling in healthy parts. As to the frequency of pulmonary disease in Bombay, where there was a high temperature and constancy of temperature, he believed that changes of temperature or exposure to cold produced bronchitis, post-nasal catarrh, &c., but did not affect the lungs; these, however, became the seat of

disease when tainted air was inspired. The prevalence of pulmonary disease in Bombay appeared to be due to blood poisoning.

Dr. Gibbon insisted on the importance of the systematic chemical and bacteriological examination of air in all cities and towns.

Dr. Nasmyth had investigated the air of mines, and his experience was that the air of coal mines was much purer than the air of an ordinary inhabited house. He pointed out that the organic impurity of any given atmosphere could not be measured by the number of organisms that it contained, the number of these organisms depending upon other conditions. Near habitations the number of micro-organisms increased largely in the air. He regarded it as very important that the air of mines should be subjected to systematic examination.

On the Effects of the Respiration of Carbonic Acid on Man.

BY

W. MARCET, M.D., F.R.S.

The subject is dealt with under three headings:—

Firstly. The source of the presence and accumulation of carbonic acid in the air breathed.

Secondly. The action of re-breathed air on the human body.

Thirdly. The action of carbonic acid gas breathed in volumes which either produce insensibility or prove fatal.

Firstly. The source of the presence and accumulation of carbonic acid in the air breathed.

This is derived principally from the decomposition of organic matter in the earth, and also in some measure from the consumption of coal. The amount of coal consumed in London and 15 miles around is about 9,400,000 tons per annum, which would give out 28,866,867 tons of carbonic acid, equal to 3·53 cubic miles of that gas. A source of carbonic acid, perhaps least thought of, is derived from the process of fermentation, as in the manufacture of beer; this gas is usually lost, but it is now, in some instances, collected from the vats, condensed into the liquid form, and used mostly for refrigerating purposes. The amount obtained from Messrs. Guinness and Co. is said to reach the enormous figure of 32 tons per diem. Again, the inhabitants of large towns must contaminate the air with their breath. The occurrence of any great excess of carbonic acid in the atmosphere is prevented, however, by the extreme diffusibility of this gas, so much so, that under a comparatively clear sky in the streets of a large town like London, there are barely more than four parts in 10,000 of air, while in the country the proportion may be considered to be between 3·5 and 3·8 parts.

I have made experiments relating to this subject in conjunction with my friend Mr. Landriset, D.Sc., of Geneva. They have been

recorded in the "Archives des Sc. Nat. of Geneva," and subsequently in the "Journal of the Meteorological Society for 1887." Our object was to find out if the proportion of atmospheric carbonic acid varied between such different levels as the town of Geneva and the highest point of the Jura Mountains, called the Dole, the difference in altitude being 4,193 feet. Former experiments on this subject by Th. de Saussure and P. Trochut had given different results; de Saussure found an increase of CO_2 in higher altitudes and Trochut a decrease. Our experiments were undertaken simultaneously at both stations, and the state of the weather was carefully recorded at the time, a precaution the other observers do not appear to have taken. Fifty analyses were made altogether, by Pettenkofer's method, at both stations inclusively, and the results show distinctly that in fine, clear weather, there was no difference between the proportions of CO_2 in the air of the two stations; therefore, under a cloudless sky, the carbonic acid diffuses equally throughout the atmosphere. Three experiments made on the mountain while the observer was in a fog or cloud, the corresponding experiments near Geneva being carried out in fine weather, gave 3·24 parts of CO_2 for the high station, and 3·88 for the low station and in clear weather; on another occasion, one experiment on the mountain while in the clouds gave 2·94 of CO_2, while three-quarters of an hour afterwards, the fog having temporarily disappeared, the sun came out brightly and the CO_2 rose to 3·91 parts, falling again when the cloud formed afresh round the observer. It follows, therefore, that on the top of a mountain there is less CO_2 in a cloud or fog than in fine clear weather.

From Dr. Russell's experiments, and those I have also made on the same subject, there can be no doubt that the very reverse takes place in large towns in foggy weather; when the streets of London are obscured by a dense autumnal fog the atmospheric CO_2 is greatly increased. This is clearly due to the carbonic acid generated in towns being absorbed by fogs, while the diffusion of the gas is much less rapid through fog than through the atmosphere when clear. But on the top of a mountain the CO_2 formed on the spot is small, and when, after diffusing through a cloud, it reaches the outside, the tension of the gas is rapidly increased by the sun's action, and it escapes. This same tension will prevent the cloud from absorbing CO_2 from below, and so the cloud loses its atmospheric CO_2.

Secondly. The action of re-breathed air on the human body.

According to E. A. Parkes, the effect of fœtid air containing organic matter produced by respiration is very marked on many people, causing heaviness, headache, and in some cases nausea. It is stated, in this author's "Manual of Practical Hygiene," p. 115, that from experiments on animals, Gavarret and Hammond have found that the organic matter of the breath is highly poisonous. Besides CO_2, we have certain volatile constituents of food, such as alcohol, garlic, &c., which are found in expired air after being swallowed. Like all other substances ejected from the body, such gaseous products must be unfit for use, and injurious in a concentrated form, but it is also very possible that

some nitrogenised organic matter, not present in food in a volatile form, is given out from the lungs. Expired air invariably discolours potassium permanganate, gives rise to the formation of sulphurous acid when passed through sulphuric acid after filtering through cotton wool, and can be made to yield ammonia. As to the unhealthy action of ill-ventilated dwellings, an interesting paper in the "Phil. Trans." for 1887, by Messrs. Carnelley, Haldane, and Anderson, shows that there is a great increase in the mortality of children, especially under five, who inhabit one-roomed houses over those in four-roomed houses, and that this is owing to the accumulation in the air of carbonic acid, micro-organisms, and other atmospheric impurities.

I have lately carried out experiments on re-breathing air, which are described in the "Proceedings of the Royal Society" for the present year. The experiments were made on four different persons in a state of repose, the mode of breathing being perfectly natural. They began by expiring the air they breathed into counterpoised bell-jars suspended over salt water, and the CO_2 this air contained was determined; the next, or second stage, of the experiment was to re-breathe 35 litres of air from and into a counterpoised bell-jar during five minutes (inspiring through the nose and expiring through the mouth); immediately after emitting the last expiration of re-breathed air, and while taking an inspiration of fresh air, the air expired was turned into another jar by means of a three-way cock. After the third quantity of air had been collected, the air expired was directed into the first jar (now emptied) and the fourth and final quantity was taken. The carbonic acid in every case was determined by Pettenkofer's method.

The results from this inquiry were as follows:—

(1.) On re-breathing air in a closed vessel less carbonic acid is expired in a given time than in ordinary breathing.

(2.) The persons who emit most carbonic acid in re-breathed air are those who expire most carbonic acid and air in the same time in ordinary breathing.

(3.) On re-breathing 35 litres of air in a closed vessel for a period of five minutes, the volume of this air undergoes a slight reduction.

(4.) When fresh air is taken into the lungs, immediately after re-breathing air in a closed vessel, the volumes of air re-breathed and weights of CO_2 expired are greater than in ordinary breathing.

(5.) The effects produced on the chemical phenomena of respiration by re-breathing 35 litres of air in a closed vessel during five minutes have passed away in less than six minutes after the breathing of fresh air has been resumed.

In an experiment, made before the Physiological Society, the gentleman who assisted me at that time re-breathed for nine minutes the small volume of 10 litres of air; a recording instrument being connected with the bell-jar showed distinctly the increase in the amplitude of the

respirations and in the speed of the respiratory movements as the air became more and more vitiated.

My inquiry yields one result, which appears to me important in point of view of hygiene—that the effects produced by re-breathing air, I mean the increased volume of air breathed in a given time and CO_2 expired, pass off very rapidly after breathing pure air. Hence, the importance for people who are called upon to make a prolonged stay in ill-ventilated apartments to go out into the open air as often as possible, were it only for a few moments at a time, and to sleep in well ventilated rooms.

Thirdly. The action of carbonic acid gas breathed in volumes which either produce insensibility or prove fatal.

The effects produced by the respiration of air mixed with carbonic acid vary considerably according to the rapidity of the action. The influence due to the suddenness of the exposure, is well illustrated by an experiment of Claude Bernard. A sparrow was placed under a glass receiver of two litres' capacity; after two hours, it was still alive, two other birds were then introduced into the receiver and they died; the first sparrow was withdrawn an hour later, warmed and when quite well, was again introduced, when it died immediately. This experiment is very interesting in point of view of hygiene, showing that people who become gradually accustomed to a close atmosphere can exist in comparative comfort under conditions which might prove baneful, and perhaps fatal, to others used to a life in the open air.

Claude Bernard also found that carbonic acid is innocuous when injected into the veins and arteries of a dog, the gas being exhaled at the lungs; on the other hand, birds died in air containing in 100 parts:—

Oxygen	39
Carbonic acid	13
Nitrogen	48
	100

showing that when breathed, even in the presence of an excess of oxygen, the action of CO_2 is no longer the same as when injected; the injected gas is being continuously given out at the lungs, the inspired gas undergoes continuous accumulation until its proportion is too great for the maintenance of life.

I have made experiments upon myself and others, when about 35 litres of air containing from 2·5 to 4 per cent. of pure CO_2 was inspired from a bell-jar and expired into the external air. The CO_2 accumulating in the body, the effects became more marked as time elapsed; the first minute a slight want of air was experienced, but in the fourth or fifth minute, the sensation was decidedly uncomfortable, and could not have been endured much longer.

Dr. Angus Smith made investigations (published in 1872, in his book on "Air and Rain") in which an air-tight chamber containing 3·84 per cent of CO_2 was entered by two gentlemen, who got headaches

instantaneously and were unable to stay above seven or eight minutes. Dr. Smith remained in the chamber for 20 minutes, and then felt very uncomfortable, and anxious to get out. An interesting inquiry by Dr. Emmerich was made at Munich in 1887 or 1888, and published with an addendum by Dr. von Pettenkofer. Several observers, including Dr. von Pettenkofer, having entered a vault in the Institute of Hygiene at Munich in which several candles were burning, CO_2 was evolved by opening two cylinders containing the compound in the liquid form; in about a quarter of an hour two of the candles went out and several persons left the vault, only Dr. von Pettenkofer, Herr Trillich, and Herr Rats remaining, the two latter gentlemen staying until all the CO_2 in the cylinders had evaporated. The candles went out when the air contained eight per cent. of CO_2. According to other experiments by Karl Friedlander and Edwin Herter, rabbits can live over an hour in an atmosphere containing 34 per cent. of CO_2.

There are many records of accidents from the inhalation of carbonic acid gas: one of the most remarkable I ever came across is recorded in a Geneva newspaper, the "Journal de Genève," of the 7th October 1886. The account is very short, and I venture to give a verbatim translation of it. "A melancholy accident has just "thrown into a state of utter consternation the small village of "Constet, near Barsac, 30 kilometres from Bordeaux. Two labourers, "named Loubrié and Blanc, were working in a cellar belonging to "Mr. Gaussem, a merchant. Blanc observed that wine was fermenting "in a vat; he went into it with the object of pushing down the grapes, "which the evolution of gas in the fluid had driven to the surface. He "instantly fell asphyxiated. Loubrié called for help, and a man named "Finore, who was working in the neighbourhood, ran up and went "into the vat to try and save Blanc. As he did not re-appear, Loubrié "tried to rescue both men but he also perished in a like manner.

"Two courageous persons, Chassin and Puzos, went down one "after the other into the vat, notwithstanding the protests and supplications of the witnesses of this horrible drama; both of these men "met with the same fate as the others. In order to remove the dead "bodies a portion of the roof over the vat had to be demolished. "Finore alone was still breathing and there are some hopes of his "recovery."

The foregoing remarks show:—

1st. That when air containing an excess of CO_2 is breathed, the gas accumulates rapidly in the blood, and under such a condition the phenomena of nutrition are more or less interfered with; and also that people working in ill-ventilated rooms and buildings, should, for the preservation of their health, sleep in as pure an atmosphere as possible, where they will rid their blood of the carbonic acid absorbed in the day time.

2nd. That the effects produced by the inhalation of carbonic acid gas depend greatly on the rapidity of the exposure. The sudden inhalation of air containing a large proportion of

the gas may produce rapid insensibility and death; while this same air might have been breathed for some time with a certain degree of impunity, had the carbonic acid present been introduced gradually.

3rd. That when life is threatened by the inhalation of carbonic acid, there is no reason to despair of artificial respiration so long as the heart is beating; the gas will diffuse rapidly from the blood into the air with which the lungs are inflated, and will thus, be carried out of the body.

DISCUSSION.

Sir Chas. Cameron drew attention to the experiments of Dr. Hammond in the United States, 10 or 12 years ago, showing that the harmful nature of expired air was due, not to the carbonic acid, but to the organic impurities it likewise contained, and that the ill effects continued after the removal of the carbonic acid by chemical means. This is also shown by the health of those employed in mineral water manufactories.

Professor Odling pointed out that the effect of the inhalation of pure carbonic acid gas was very similar to that produced by nitrous oxide.

Friday, 14th August, 1891.

THE PRESIDENT, SIR H. ROSCOE, IN THE CHAIR.

Meteorology in relation to Hygiene.

BY

ALEXANDER BUCHAN, M.A., LL.D., F.R.S.E.

No city can be compared with London as affording the best available materials for an inquiry into the relation of weather and health: the data for the inquiry being supplied (1) from an enormous population spread over an area so restricted that it may be regarded as having one uniform climate during each of the seasons of the year; (2) by fairly satisfactorily full reports, week by week, of weather and of the number of deaths from the different diseases; and (3) by returns extending over a sufficiently long time, viz., 46 years.

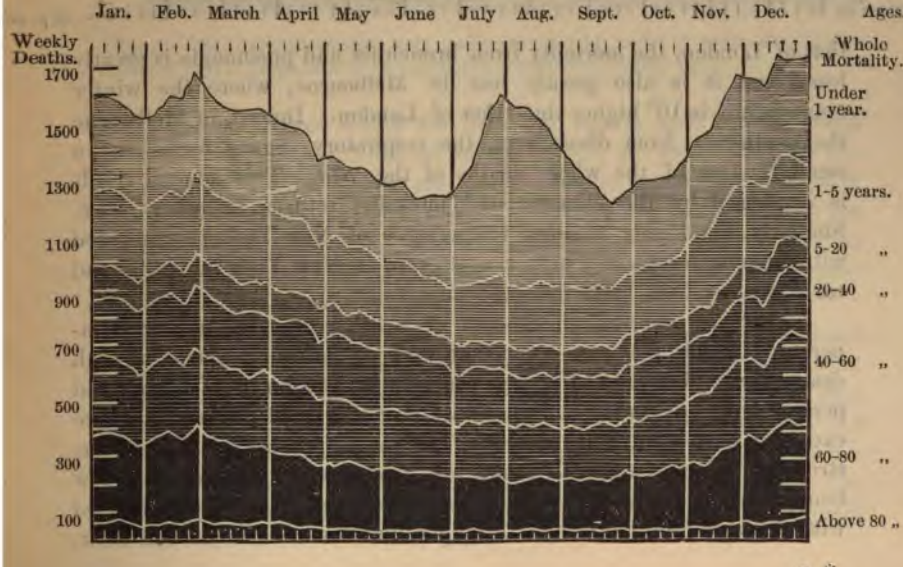
As regards such diseases as diarrhœa, bronchitis, and heart disease (Figs. 3, 2, and 6), which are to a large extent directly and immediately under the influence of temperature and humidity; and such epidemics as scarlet fever, diphtheria, and whooping cough (Figs. 4, 5, and 10), the rate of mortality from which is very largely determined by season and weather; a comparatively small number of years is required to give a satisfactory approximation of their true weekly curves or mortality. But in dealing with the data of a large number of diseases whose mortality is relatively small, it soon becomes apparent that all the 46 years are needed in order to give sufficiently close constants for the curves of weekly mortality for a considerable number of these diseases. The curves of weekly mortality thus arrived at suggest complications of special diseases and their connexion with each other, which complications would be entirely masked if monthly averages alone were employed.

The climate of London in its relations to the public health may be divided into six different types according to the season of the year, viz.:—1. *Damp and cold*, fourth week of October to third week of December; 2. *Cold*, fourth week of December to third week of February; 3. *Dry and cold*, fourth week of February to second week of April; 4. *Dry and warm*, third week of April to third week of June; 5. *Heat*, fourth week of June to 1st week of September; 6. *Damp and warm*, second week of September to third week of October.

The curve for the whole mortality (Fig. 1) shows two maxima of very different degrees of intensity; one the greatest and longest-continued

Fig. 1.

Mortality at different Ages—for both Sexes and all Causes.

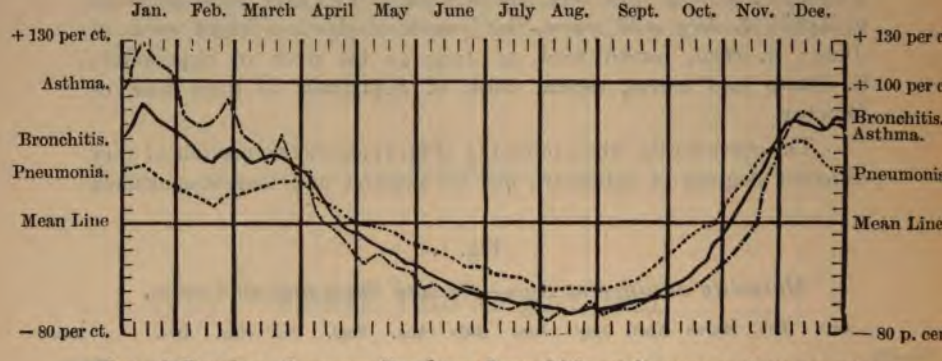


extending from November to April, and the other strictly confined to the summer months. Now the singular point of the summer maximum is that it virtually disappears if the mortality among infants under one year be subtracted from the whole mortality. Hence the most deleterious element in the climate of London to the health of the people is the low temperature of the winter months; and this remark may be extended *to all* climates in which the temperature of the winter months falls repeatedly below 40°.

Of the diseases by which the excessive winter mortality of London is occasioned, the first place must be assigned to diseases of the respiratory organs (Fig. 2), notably bronchitis and pneumonia, to which alone one-fifth of the whole mortality of London is attributable. Statistics show that the greatest fatality from these diseases occurs when the temperature is between 32° and 40°; or, say, between the temperature of the maximum density point of water and its freezing point. Thus, in New York, where the mean temperature of winter is 10° lower than

Fig. 2.

Bronchitis, Pneumonia, and Asthma—for all Ages and both Sexes.



that of London, the mortality from bronchitis and pneumonia is greatly less; and it is also greatly less in Melbourne, where the winter temperature is 10° higher than that of London. Indeed, in Melbourne the death-rate from diseases of the respiratory organs forms but a small fraction of the whole deaths of the year. This general result is confirmed by the climatic and mortality returns of other cities. Similarly, the higher summer temperature of New York as compared with London results in a higher death-rate in New York in spring and early summer from brain diseases (Figs. 7 and 8).

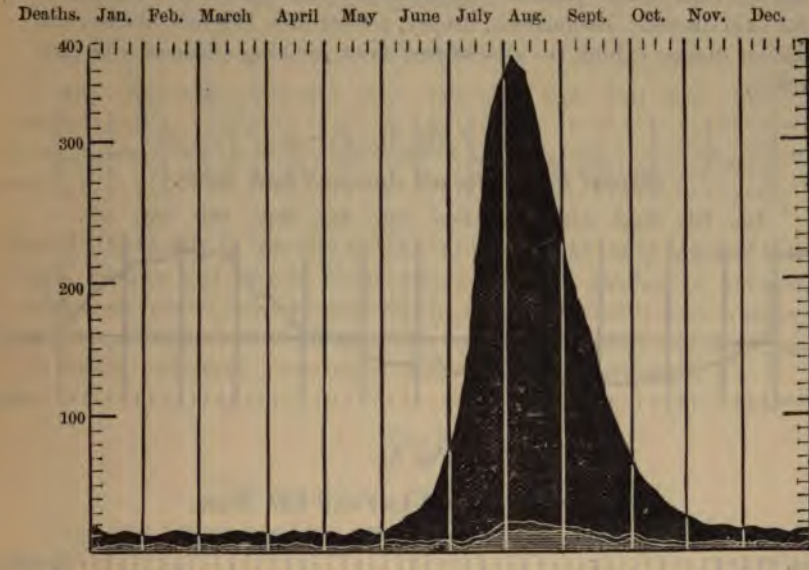
There is, however, an element of weather other than mere temperature which plays an important part in bringing about a high death-rate. That element is fog, which in proportion to its density and persistency sends up the mortality with alarming suddenness to a degree exceeded only by Asiatic cholera. Let me emphasize the fact in the strongest manner that it is not low temperature by itself, but low temperature along with dense and persistent fogs which is accompanied with this appalling mortality. A single illustration will make this clear.

Last winter was, as regards London, one of the very coldest on record. With the low temperature the deaths from bronchitis rose greatly above the average of the season, the highest in any single week being 711 during the second week of the year. But during the low temperature and dense fogs of the winter of 1880 the mortality from bronchitis rose to 1,223 during the first week of February.

In summer, when '*heat*' is the chief characteristic of the climate, the maximum at that season is caused by diseases of the abdominal organs (Fig. 3). The peculiarly malignant character of summer diarrhœa

Fig. 3.

Diarrhœa.



NOTE.—The darkest shaded part indicates deaths under 5 years, the lighter portion at foot of figure shows the deaths at successively higher ages.

among young children under five years of age is seen by the mean weekly mortality rising from 20 in the middle of June to 342 in the first week of August—when the temperature is about the average of the season. But in July 1876, when the temperature was 3°·6 above the average, the mortality from diarrhœa among children rose to 502 on the last week of that month. On the other hand, during the cold summer of 1860 the largest number for any week did not exceed 90.

Of the large British towns, the lowest mortality from summer diarrhœa is that of Aberdeen, which has at the same time the lowest summer temperature. The diarrhœa mortality of each large town rises from year to year proportionately with the increase of temperature; but the rate of increase differs widely in different towns, pointing to causes other than mere weather, these causes having heir origin in the sanitary condition of the town. The recognition of this in quite recent

years, and the measures taken to remedy matters, are among the most satisfactory outcomes of the inquiries we have now in hand.

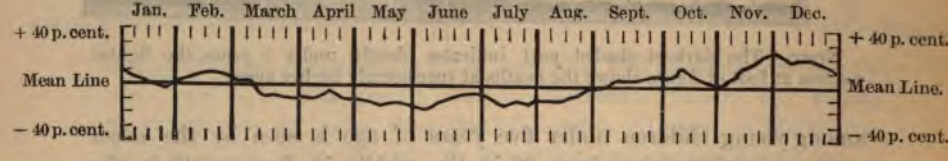
The curves suggest several contrasts and other relations *inter se*. Thus, while the whole mortality shows September and October to be two of the healthiest months of the year, the curves for scarlet fever (Fig. 4), typhoid, and diphtheria (Fig. 5) form striking exceptions. These three curves are closely related to each other, each having, however, a well-marked individuality of its own. It is a singular circumstance that diphtheria shows closer relation in the phases of its death-rate with typhoid than with scarlet fever. The curve for mortification is substantially that of nervous diseases, and the curves for erysipelas and puerperal fever are in all essential respects the same. The curve for old age runs exactly parallel with the curve for paralysis. The curves for skin diseases, rheumatism, dropsy, pericarditis, Bright's disease, and kidney disease exhibit the closest and most striking alliances with each other.

Fig. 4.

Scarlet Fever—for all Ages and both Sexes.

Fig. 5.

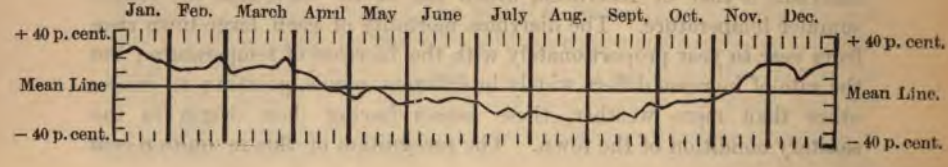
Diphtheria—for all Ages and both Sexes.



Lastly, while diseases of the abdominal organs attain their greatest mortality when temperature is highest, diseases of the respiratory organs and of the circulatory system (Fig. 6) when temperature is lowest,

Fig. 6.

Circulatory System—for all Ages and both Sexes.



nervous diseases (Figs. 7 and 8), phthisis (Fig. 9), and whooping-

Fig. 7 (New York).

Meningitis and Encephalitis—for all Ages and both Sexes.

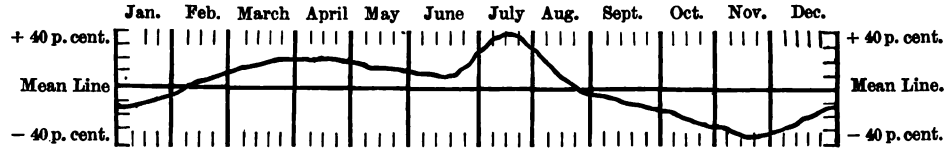
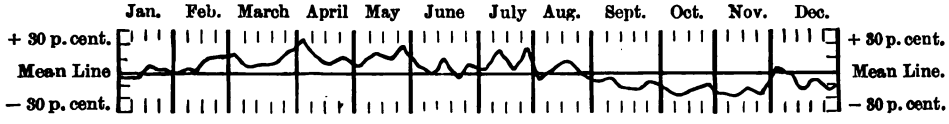


Fig. 8 (London).

Cephalitis.



cough (Fig. 10) in the dry weather of spring and early summer, and skin diseases and certain fevers during the raw weather of autumn and early winter, the diseases which are quite removed from weather influences (such as peritonitis) exhibit curves which show no obedience to season, but merely a succession of sharp irregular serratures.

Fig. 9.

Phthisis—for all Ages and both Sexes.

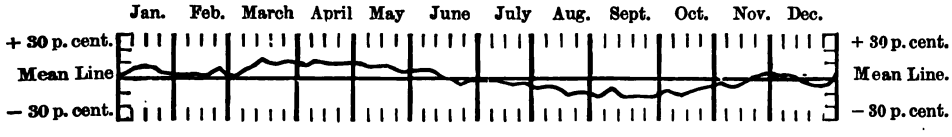
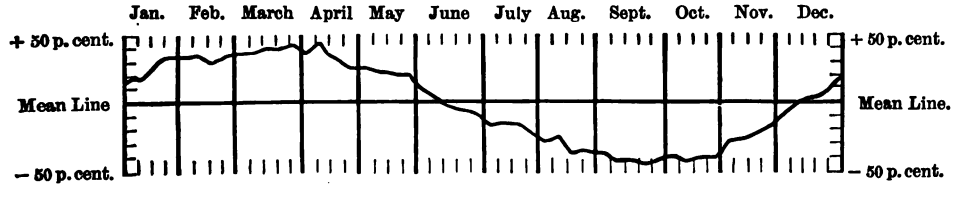


Fig. 10.

Whooping Cough—for all Ages and both Sexes.

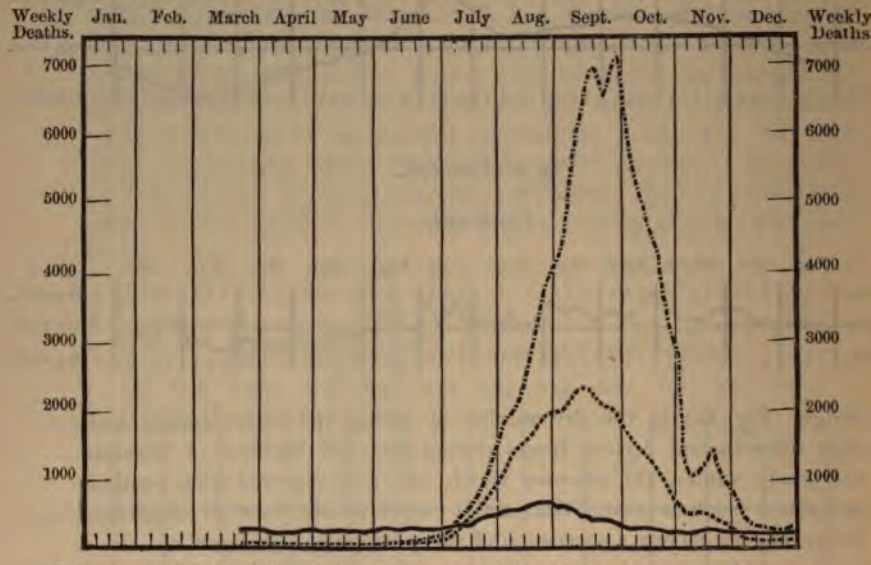


The weekly returns of the last six plagues of London (Fig. 11), published in 1662 by John Graunt under the auspices of the Royal Society, have been examined in view of the results now established. The manner in which

the Plague, as a death-producer, obeyed the weather, is striking. It did so exactly as we now see bowel complaints to be influenced by weather.

Fig. 11.

SHOWING BY THREE CURVES—(1) Doubly-dotted Line or Highest Curve, Weekly Mortality during the Great Plague in 1665; (2) Lower Dotted Curve, Mean Weekly Mortality of the Six Plagues; and (3) Solid-lined Curve, Mean Weekly Mortality from all other Diseases during continuance of the Six Plagues.



The curve for the Plague bears no resemblance whatever to the curve for typhus, or indeed to that of any disease except bowel complaints. This close resemblance suggests whether there was not a closer alliance between them than has been suspected. If the results now ascertained be regarded as a fair outcome of our inquiries into the relations of weather and health, it is plain that such investigations may point to a set of morbid processes which have been cloaked by prominent phenomena, apparently of a primary, but in reality of a secondary character.

DISCUSSION.

Dr. G. B. Longstaff stated that meteorological curves and curves of deaths, however closely related on cause and effect, could not possibly correspond exactly, owing to the fact that the interval between the death and its registration averaged about five days, and the interval between the commencement of an illness and a resultant death was of uncertain and often considerable duration. He stated that, in his opinion, meteorological changes were not of themselves the cause of death, though the number of deaths appeared to be a function of those changes. Fog alone, or cold alone, did not directly cause the deaths from respiratory diseases; but there was a *tertium quid*, perhaps the germ of ordinary communicable catarrh. Fogs must be distinguished into

those mixed with smoke and those free from smoke, the latter probably not having any pathological significance. Again, smoke fogs must be divided into those in contact with the ground and those forming a pall overhead, probably the latter would be found to have comparatively small influence upon the mortality. He explained the very close relation between the curves of apoplexy and mortification by the fact that both are symptoms of disease of the arteries chiefly in old people; that cold raised the blood pressure and hampered the circulation, resulting in some cases in rupture of an artery and apoplexy, in other cases in stopping of the local circulation and mortification. In conclusion, he stated that Messrs. Buchan and Mitchell deserved great credit for their valuable improvements in the methods of exhibiting statistical results.

Dr. Tripe, Medical Officer of Health, Hackney, said that Dr. Longstaff had already referred to the interval which elapsed between the death and registration, and also to that between the weather causing the illness and the deaths. He had in his investigations allowed two weeks, but he now thought that to be too small an interval except as regards diarrhœa and perhaps diphtheria. In the former, the action of heat is rapid so soon as the temperature of the soil at a depth of six inches, or of the Thames, reaches 65°. As to the effect of fogs, they vary very much according to their density and quality. This was well shown by the fogs during January and February 1880, when they were so dense as to prevent him from seeing the kerb, and the number of deaths from inflammatory diseases of the lungs was then more than double those in 1891, when the temperature was lower than in 1880.

Mr. W. North called attention to the curves drawn by Professor Tacchini, showing the relation between the rainfall in the months of March, April, and May, and the number of cases of fever in the Province of Rome in the autumn. As the result of his own experience in the Roman Campagna, the author was led to entertain grave doubts as to the possibility of explaining the phenomena of intermittent fever on the hypothesis of a pathogenic organism; the relation of malaria to local climatic conditions is no longer a matter of question, and is so close that it appears to be not unreasonable to regard the latter as powerful factors in causing, if they are not themselves the cause of, the disease. It appears that the mode of operation of these climatic changes on the organism may be accounted for on some such hypothesis as the following: the temperature of the body may be reasonably regarded as the result of the interaction of two rhythmically acting forces, interference with one or other of which will produce the phenomena of beats, to which the regular intermission of malarial fevers have at least a very close resemblance.

Dr. Russell pointed out, with regard to London fogs, that when there was a great increase of death-rate a low temperature always accompanied the fog, but that there were, on the other hand, several cases of dense fogs without decrease of temperature, and then the death-rate did not fall below the average; hence it appeared unfair to say that the fog itself was the sole cause of the great mortality.

In reply to Dr. Russell, **Dr. Buchan** stated that he fully agreed that it was impossible to determine how far the increased mortality in cold foggy weather was due to the fog, and how much to the low temperature; but he wished to emphasise the fact that it was the combination of the two which was so very fatal.

Influenza and the Weather of London.

BY

Sir Arthur Mitchell, K.C.B., and Dr. Buchan.

This subject was investigated by us in the spring of 1890, and the results were published in the Journal of the Scottish Meteorological Society. In that paper are summarised the statistical facts relating to weather and influenza up to that date, extending from 1845 to 1890. These have been published in the weekly reports of the Registrar-General. Of the results then arrived at (that is, previous to the last epidemic), the following is a brief summary:—

It was found that the distribution of temperature and the distribution of deaths from influenza during the weeks of the year were inversely related; that when the mean temperature is low, the mean death-rate from influenza is high; and when temperature is high, the number of deaths from influenza is low. Further, the distribution of deaths from influenza is essentially the same distribution as that for bronchitis and pneumonia, or, speaking generally, for diseases of the respiratory organs.

Since registration of deaths commenced in London, deaths from diseases of the respiratory organs (*vide* Fig. 2)* have been shown to be most numerous during the winter months of the year; and, with some marked differences, there is substantial agreement in the annual distribution of deaths from the different diseases of the respiratory organs. During exceptionally severe winters and during dense fogs there is an exceptionally high mortality from bronchitis and pneumonia; and an enormous increase in the death-rate from these diseases during extremely cold weather and densely foggy weather has been an unvarying and apparently an inevitable consequence.

Similarly, deaths from heart disease (*vide* Fig. 6), including the other diseases of the circulatory system, and deaths from phthisis (*vide* Fig. 9), reach their annual maximum fatalness when the mean annual temperature is absolutely lowest, and when the east winds of early spring acquire their greatest frequency and malignancy respectively; and when it happens in any year that these features of the weather are more pronounced than usual, so is the excess of the mortality from these diseases also more pronounced.

Now when the death-rate from diseases of the respiratory organs, of the circulatory system, brain diseases (*vide* Figs. 7 and 8), or phthisis have strikingly exceeded the per-centages due to the temperature and fogs prevailing at the time, it has been found that something of an exceptional character has been in operation at the same time; and that

* The figures referred to are those contained in the preceding paper on *Meteorology in relation to Hygiene*, p. 98, *ante*.

something apparently lowering the public health has been the prevalence of influenza in a more or less epidemic form. At these times, it was noted that the diseases which were abnormally increased were, broadly speaking, just those diseases which annually go to swell the death-rate at the times of the year when influenza happened to be clearly epidemic. In other words, these were the diseases with which occurred the more serious complications with influenza.

It is remarkable that though during these 46 years the deaths from influenza were virtually restricted to the cold half of the year, yet when the epidemic set in, the degree of fatalness has been wholly uninfluenced by the changes of temperature, sometimes strikingly large and sudden, that occurred during the weeks when the mortality from influenza was great.

The last epidemic of influenza in London may be considered as having commenced about the middle of April 1891; the deaths in the third week of that month were 10, after which they rose with alarming suddenness week by week to the maximum of 319 in the third week of May; and since then the numbers have been 310, 303, 249, 182, 117, 56, 40, 29, 18, 17, and 6 in the first week of August. During these 16 weeks, the total number of deaths has been 1,925 recorded as caused by influenza alone, and to this must be added a very large number due to complications with other diseases.

The excess over the average mortality was comparatively small at all ages under 20; but above 20 the excess of the mortality rose steadily with age. Thus for the six weeks beginning with May 16th, the death-rate at 80 years and upwards was 117 per cent. above the average of the season. The deaths from influenza account only for a very small fraction of the increased total mortality of London during the epidemic. Other diseases showed an extraordinarily high death-rate of which the weather at the time affords no explanation; again pointing clearly to something of an exceptional character in operation at the time.

The weekly mortalities from the various registered causes of death have been compared with their averages for these weeks, with the result that during the epidemic the death-rate was enormously increased from diseases of the respiratory organs, the circulatory system, brain diseases, and phthisis.

Now the winter of 1890–91 was, in London, one of the severest on record, the mean temperature for the eight weeks beginning with the last week of November having been 10°·4 below the average. This unprecedentedly low temperature, prolonged through many weeks, was accompanied with a correspondingly high mortality, particularly from diseases of the respiratory organs and the circulatory system; and thus during last winter the death-rate was unusually large from these diseases.

The most noteworthy circumstance connected with the recent epidemic of influenza is the lateness in the season of the time of its occurrence, the time being the end of spring and the beginning of summer. All the previous epidemics, for which trustworthy weekly

INFLUENZA, 1891.

PER-CENTAGES by which the Death-rates of London, from different Causes of Death, were above or below the Means of the previous 10 Years, 5·5 per cent. being added for increase of Population. Figures in *italics* show a per-centage above the Mean; and figures in Roman type a per-centage below it.

—	Nov. 1890.		Dec. 1890.					Jan. 1891.				Feb. 1891.				March 1891.					April 1891.				May 1891.				June 1891.				
Week	47	48	49	50	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Mean temp.	7°7	7°0	6°2	11°0	13°5	11°7	10°6	10°8	7°7	4°5	5°4	0°6	1°8	1°4	1°2	5°3	5°4	1°9	0°8	2°0	7°6	3°6	4°5	0°6	2°2	4°4	7°3	4°8	2°2	3°6	3°9	3°9	2°6
Sex :—																																	
Males	2	8	7	5	25	16	34	24	18	7	4	9	4	4	15	14	–	2	4	6	4	11	8	27	28	45	38	49	42	28	32	14	0
Females	9	5	2	1	34	25	38	34	36	18	1	11	12	7	13	14	9	4	12	1	2	5	8	22	35	48	37	63	60	38	38	8	9
Total	5	6	4	3	29	20	36	29	27	12	2	10	8	5	14	14	4	3	8	3	1	3	8	25	31	46	37	55	50	33	35	11	5
Ages :—																																	
0–5 years	10	24	4	6	2	3	4	4	1	3	12	27	23	11	3	3	13	12	20	9	12	12	10	4	1	11	4	14	13	1	4	8	23
5–20 „	6	14	1	8	15	14	3	14	6	30	20	10	20	4	11	7	17	8	4	–	4	5	7	9	10	11	22	22	2	7	2	6	10
20–40 „	1	1	6	5	20	13	6	31	28	1	14	15	3	2	20	10	14	7	3	–	2	1	18	22	23	36	58	42	46	15	40	15	10
40–60 „	1	2	13	4	44	29	56	44	88	31	22	7	9	1	30	40	20	7	8	17	8	32	23	53	63	67	76	95	65	56	38	29	12
60–80 „	11	4	17	22	60	56	89	79	65	53	13	11	11	9	30	24	2	10	3	13	17	20	30	71	73	100	104	127	112	100	87	39	18
80 „	8	16	21	32	61	73	80	53	78	55	32	7	9	4	12	12	20	6	8	5	7	27	13	56	64	94	100	118	138	120	114	55	24
Influenza	3	2	1	1	1	3	1	3	3	1	2	3	2	–	2	2	2	1	3	7	3	2	10	37	148	266	319	310	303	249	182	117	56
Circul. system	8	7	30	23	55	30	50	41	42	27	4	–	8	19	33	32	10	1	–	26	19	40	56	40	35	35	46	89	80	51	32	20	14
Pneumonia	27	6	39	22	84	29	80	93	73	66	50	3	31	34	70	97	73	21	24	51	30	59	61	123	120	121	129	114	110	116	112	63	48
Bronchitis	1	18	3	6	62	79	104	77	88	46	8	24	15	1	41	30	2	1	18	9	4	6	9	40	74	111	116	142	132	109	128	40	6
Pleurisy	166	9	30	54	139	62	106	157	–	32	116	7	43	43	55	80	118	126	3	12	60	73	19	153	124	12	24	28	50	111	30	43	38
Croup	32	40	1	24	56	33	33	36	41	47	60	33	14	40	20	7	50	25	10	18	36	16	23	30	18	48	22	31	9	92	46	54	53
All resp. organ diseases.	2	12	–	2	60	58	82	70	68	42	13	18	8	5	42	37	11	5	8	3	7	18	22	60	72	93	100	116	119	91	99	39	14
Phthisis	4	10	15	7	27	5	2	1	14	4	25	3	3	2	3	6	7	10	6	2	15	18	2	1	8	26	3	27	19	8	15	11	6
Enteritis	21	53	72	55	78	15	45	3	6	36	75	73	14	22	98	91	92	5	29	23	39	58	58	40	83	90	22	64	26	122	15	28	17
Apoplexy	2	15	2	12	10	4	28	19	7	2	14	19	16	8	29	15	14	7	2	32	31	1	9	65	23	21	35	29	12	3	17	6	24
All brain diss.	3	19	–	4	10	1	12	12	14	2	13	6	23	13	4	13	10	–	2	7	3	9	8	4	9	13	13	25	13	5	9	2	10
Epilepsy	14	13	13	21	124	43	1	49	38	67	83	26	15	67	13	69	21	27	55	33	39	16	13	67	54	57	42	88	41	19	46	25	41

statistics exist, occurred either in winter or early spring. From the termination of the severe weather of winter in the end of January to the outbreak of the epidemic in the middle of April, the death-rate from these diseases, as well as the general death-rate was very greatly less than what had been before and what followed. It was in truth the normal death-rate which was to be expected to accompany the, on the whole, greatly milder weather during these 12 weeks.

The mean temperature of the 11 weeks ending with June was exactly the average of past years, the weekly averages varying from 4°·4 above the average in the second week of May to 7°·3 below it in the following week. On the whole, then, the period was of the average temperature of the season, with fluctuations of temperature somewhat larger than usual.

In 1875 we showed* that from the middle of April to the end of June the death-rate from diseases of the respiratory organs, the circulatory system, brain diseases, and phthisis steadily diminish week by week, so that with the temperature and weather which actually occurred during this period deaths from these diseases might have been expected to have fallen off week by week.

But, with the setting-in of influenza, deaths from these diseases increased with alarming suddenness, even though, be it noted, deaths from the same diseases had been exceptionally heavy during the previous December and January.

The period of the year from the third week of April to the end of June is characterised by dryness and warmth, and statistics show it to be one of the healthiest times of the year. Indeed, at this time, no disease whatever shows a rapid increase in its death-rate, and only a few, notably bowel complaints, show the setting in of a rise in June from the annual minimum, as shown in Fig. 3.

Now, during this epidemic, no bowel complaint, with the single exception of enteritis, exhibited an increase in its death-rate; and further, no increase was apparent from any of those other diseases whose mean weekly death-rate at this season happens to be moderately high.

But the remarkable thing is this, it was just the same diseases whose death-rates were so exceptionally and enormously swelled during the influenza epidemic of January and February 1890 that have exhibited a similar exceptional and enormous increase to their death-rate.

It is a singular circumstance that in both the last influenza epidemics, the one a winter and the other a summer epidemic, croup has stood out as an exception to the other diseases of the respiratory organs, in uniformly showing a death-rate below its average; and, on the other hand, enteritis stands out as an equally striking exception to other bowel complaints, in exhibiting a death-rate above its average.

Accepting the mortality returns as revealing the diseases with which the complications with influenza occur, the important conclusion

* Journal of the Scottish Meteorological Society, Vol. IV., p. 187.

is arrived at that the complications of influenza are with special diseases only, irrespective of season. The increase to the death-rate from pneumonia, bronchitis, heart disease, and phthisis are equally enormous, whether the epidemic occurs at the season when their normal death-rates are highest, or at another season when the death-rates are falling to their annual minima.

In discussing the spread of the germs of diseases from one country to another by the intervention of winds, it has hitherto been universally assumed that is only the winds blowing over or near the surface of the earth which are concerned in the distribution of these germs. If these surface winds do not account for the successive appearances of the epidemic in different countries, it is concluded that the germs have not been transported by the winds.

This, however, is only a mode of looking at the subject which ignores the recent developments of meteorology and its teachings regarding atmospheric circulation through cyclones and anti-cyclones. As is now virtually proved, the winds in a cyclone are drawn inwards towards its centre, and then ascend in a vast aerial column to the upper regions of the atmosphere, whence again they flow as an upper current towards any anti-cyclone that may surround them. Thereafter they slowly descend along the centre of this anti-cyclone to the earth's surface, over which they are carried in every direction.

Suppose, for example, there were, as often happens, a cyclone in Russia, a vast column of air ascends from the surface, carrying with it particles of dust, germs, and other light impurities. These are then conveyed by the upper current to an anti-cyclone overspreading Western Europe, as in the supposed circumstances so often happens, and thereafter they descend to the surface with the descending current and are distributed over Western and Central Europe by winds from all points of the compass. Owing to the known rapidity of these aerial movements, two, or at most three, days are amply sufficient for this distribution.

DISCUSSION.

Dr. G. B. Longstaff, after paying tribute to the great importance and high value of the work of Sir Arthur Mitchell and Dr. Buchan, and expressing the hope that their collected papers would be republished in a more accessible form, pointed out that whenever a new disease appears medical men assign other diseases as the cause of death until the disease becomes prevalent, and that for this reason many of the deaths ascribed to bronchitis, &c. ought to have been recorded as cases of influenza. Nevertheless, the Registrar-General's returns afforded on the whole reliable average information, as was shown by the tabulation of enteritis and diarrhœa.

Dr. Gilbert stated that although the rainfall in February 1891 was smaller than that recorded in any previous month, the amount of nitrogen it contained in the form of ammonia and nitric acid was almost as great as that found in the rainfall of February in the two previous years, although this amounted to nearly 1 inch in 1890, and to 2 inches in 1889.

The quantity of chlorine in the water in February 1891, was the smallest on record, this being possibly due to the unusual absence of wind.

The Hon. Rollo Russell said that there were no authentic accounts of an attack of influenza occurring in mid-ocean or at any of our light-houses. The disease was due to infection carried along the main lines of communication. The large towns were attacked in the first instance, and then the outlying districts. The march of influenza over Europe took the same lines and came from the same locality as cholera.

Dr. Tripe (Hackney) said that true influenza was invariably preceded by epidemic pneumonia. In Hackney, horses and cats during 1889–90 were attacked by influenza six weeks before any human beings, but during the last epidemic only a short time before.

Dr. Mortimer Granville had been much impressed by the apparent prominence of almost purely physical factors in the production, in influenza, of the high bodily temperature which had been considered characteristic of the disease. These factors were, first, the displacement of the blood from the centre to the periphery by the depression of vaso-motor activity produced by the onslaught of the specific poison, whatever it was, that caused the malady; second, the conductivity of the atmosphere, dependent rather on density than temperature, although temperature came largely into play. He considered that this conductivity of the atmosphere was a factor of great importance in the production of high surface temperature, and that the duration of the disease depended especially on external conditions as regarded temperature, and particularly, as above stated, on the density of the atmosphere and its conductivity rather than on the personal state of the patient. After all other symptoms had disappeared a daily rise and fall of temperature was observed in the cases of persons resident in districts where the atmosphere is generally dense and cold. The weather played a most important part in determining the prevalence, the severity, and duration of the disease.

Mr. J. T. Roe supported the theory that the source of the influenza was to be found in the great floods in China and the resulting decay of large numbers of unburied bodies, and illustrated the possibility of the diffusion of the germs by a comparison with the distribution of dust from the Krakatoa explosion of 1883.

In reply to the Hon. Rollo Russell, **Dr. Buchan** stated that the outbreak of influenza at sea mentioned in his paper could only be accounted for on the theory of atmospherical distribution of the germs.

The President remarked that the great prevalence of influenza among members of the House of Commons appeared to be due to infection introduced by the witnesses who attended the Committees on the two important Railway Bills of the session.

Recent Hygienic Improvements in the Manufacture of Bread.

BY

JOHN GOODFELLOW, F.R.M.S., Hon. Consulting Chemist to the Master Bakers' Protection Society.

Bread is such a universal and important food that any improvements in its manufacture and quality deserve recognition and consideration,

and should prove interesting to all hygienists. It will be convenient if the subject be divided into two parts :—

1. Improvements in whole-meal bread.
2. Improvements in other breads.

The writer, from many experiments performed on himself, his assistants, and on young animals, for the purpose of his work on bread as a food, has come to the conclusion that ordinary whole-meal bread is not a desirable food and acts injuriously on the intestinal tract by unduly stimulating the muscles and nerve-centres of the bowels.

The chief objections to ordinary whole-meal bread as a food are :—

1. The large per-centage of waste, averaging about 12½ per cent.
2. The increased waste of other foods produced by the ingestion of whole-meal bread.
3. The unpleasant taste produced by the comparatively flavourless particles of bran.
4. The irritating action of the bran.
5. The rapidity with which whole-meal bread becomes dry and stale.

The large per-centage of waste is a most serious objection to ordinary whole-meal bread, especially if it be taken in large quantities. It constitutes a loss of energy to the body, inasmuch as force is used to digest the extra quantity of food which must be taken to equalize the waste.

The waste in fine white bread only amounts to about 4½ per cent., so that whole-meal bread is not nearly so thoroughly digested as white bread, and its ingestion leads to an increase in the waste of other foods.

In a subject experimented on by the writer, in December 1890, it was found that when milk alone was used as a food the waste averaged about 8 per cent. ; but when ordinary whole-meal bread was used with the milk, the waste in the milk rose to nearly 11 per cent.

The irritating action of coarse whole-meal bread depends on the bran. The coarse bran particles act as mechanical stimuli, both to the nerve centres and the muscles, and unduly increase the peristaltic action of the intestines.

The stimulation often passes beyond the innocuous stage, and severe diarrhœa may be brought on by the excessive irritation of the bran. The writer has found indications that the villi of the intestines may be considerably modified by a continued ingestion of coarse bran, and he believes that this modification may have an effect in reducing the absorbing power of the villi.

Many medical authorities assert that slight chronic inflammation may result from the continual ingestion of coarse bran, and the author must admit that over and over again the post-mortem appearances of the animals he has experimented upon have been quite compatible with such a view.

The unpleasant flavour of coarse whole-meal bread is probably caused by the bran particles, which produce in the mouth an acute sense of *touch*, but not a very decided taste.

Some students undertook to test this point under the writer's direction, and they affirmed that flavourless particles very materially altered the taste of nearly every food tried.

They found, also, that the finer the particles the less they affected the flavour of the food with which they were mixed.

Objection number 5 is an important one. Very few people can partake of a stale whole-meal loaf with any degree of pleasure. It is well-known that staleness is not altogether due to a simple evaporation of water. There is a molecular change which goes on slowly, and which is an important factor in producing a stale loaf.

In ordinary whole-meal bread these changes go on very rapidly, and the bread after 24 hours is comparatively flavourless and distasteful.

The first four objections depend on the presence of coarse bran particles. It appears that very fine particles of bran do not produce such undesirable effects on the body as those which have been ascribed to coarse bran, so that the hygienic improvements in whole-meal bread must necessarily take the form of—

1st. Obtaining a *fine* bran in the loaf.

2nd. The preparation of so *dry* a meal that the bread takes up a large proportion of water, which is so intimately incorporated with the constituents as to delay those internal changes which result in a stale loaf.

Other minor improvements may also be referred to, affecting the digestibility, purity, flavour, &c., of the bread.

Number 1. Triticumina Bread.—This is a special whole-meal bread in which the bran particles are very fine, and shows what can be done in this direction. It is prepared from a special meal, ground by powerful steel machines, in which the bran is literally cut up into fine particles.

The waste in this bread, as ascertained by personal experiments, is only 7½ per cent., as compared with 12½ per cent. in ordinary whole-meal bread. The bran is so fine that it does not irritate the intestines like the coarse varieties of brown bread.

That it is perfectly possible to manufacture whole-meal bread which shall keep moist for two or three days is proved by the fact that this bread is palatable and soft after being kept three days. This is not only due to the moisture which it contains, but also to the large proportion of *soluble* matter present. The flavour of the bread is very pleasant owing to the large quantities of sugar and dextrin which it contains.

This bread is also distinctly very digestible. The starch is in a very assimilable condition, and there is about 50 per cent. more soluble matter present than in ordinary whole-meal bread.

This very desirable result is obtained by allowing the grain to undergo the first stages of germination, and subsequently kiln-drying it at a low temperature.

Number 2. "Cyclone" Bread is very interesting as marking a new departure in the preparation of whole-meal. The wheat grains are pulverized in sealed chambers by means of air-currents produced by fans

i p. 1838.

rapidly revolving in different directions. The grains are reduced to a state of fine division by their own momentum, and the result is a fine whole-meal. The advantages of this method are many. In the first place the meal is thoroughly aërated, and, secondly, there is no metallic or stony adulteration; thirdly, the meal is very free from microbes and other aërial impurities, for the air is filtered before being delivered to the chambers.

These two specimens demonstrate the possibility of manufacturing whole-meal bread in which the bran particles are so fine as to entirely obviate any irritating effects.

Improvements in non-whole-meal breads.

These may be divided into :—

1. Improvements in white bread.
2. Improvements in brown bread.

White bread is certainly deficient in proteid material, fat, and mineral matter. The reason of this is well-known. Fine white flour is obtained chiefly from the centre of the grain, and the bran and the germ are rejected. The bran and the germ are the portions of the grain richest in proteids, fat, and mineral matter, while the central part is poor in proteids and phosphates, and rich in starch.

Hence it follows that bread made from fine white flour is also deficient in nitrogenous matter, fat, and inorganic constituents, and is correspondingly rich in starch.

Any process, therefore, which secures :—

1. A higher per-centage of proteids;
2. „ „ fat;
3. „ „ phosphates;

may be regarded as an hygienic improvement in the quality of the bread. There appears to be a consensus of opinion that if a larger per-centage of our carbo-hydrate food took the form of soluble bodies (sugar and dextrin) the economy would gain considerably by such a substitution. Any process, then, which secures this, may also be regarded as an hygienic improvement, inasmuch as the bread would be more digestible.

The standard ratio of nitrogenous matter to carbo-hydrate material may be taken as 1 is to 3·2. The ratio in ordinary fine white bread is as 1 is to 7.

Number 3. Black's Fermented Bread is a white bread which is characterised by a high per-centage of nitrogen.

This result is obtained by a special process in which "strong flours" are taken and formed into dough, and then treated with lime-water. The gluten is concentrated, and part of the starch precipitated, so that a dough is obtained very rich in proteid material. This dough is then added to ordinary dough, and the result is a mixture with a very high proportion of albuminoid matter.

This characteristic is obtained without any deterioration of texture or flavour, and the ratio of nitrogenous matter to carbo-hydrates is as 1 is to 3·6, very near the normal.

This bread, though white, has quite as high a per-centage of proteid material as fine whole-meal.

Number 4. Diastase Bread is a variety with a very high per-centage of soluble carbo-hydrates, chiefly in the form of maltose. The starch is also in a very assimilable form. The bread has a very fine texture, and is one of the best flavoured of the white breads. It keeps moist far longer than ordinary white bread, for the diastase so acts on the starch as to produce soluble bodies which confer this characteristic on the bread.

The ratio of nitrogenous matter to carbo-hydrates is about the same as in ordinary fine white bread, but the bread is far more digestible, containing quite 80 per cent. more soluble carbo-hydrates.

This result is obtained by the addition of "diastase" to the dough, which acts on the starch, converting it into several forms of dextrin and sugar. The whole series of intermediate changes have not yet been fully worked out, but it appears that maltose is chiefly formed as a final product, and one of the achro-dextrins. The diastase does very little work during the doughing stage, but when the dough is introduced into the oven it rapidly acts on the gelatinized starch, until its power is destroyed by the heat of the oven.

The author has ascertained that 15 minutes is the average time during which the ferment acts on the starch in the oven, quite long enough for the diastase to produce a considerable quantity of sugar.

Brown Breads.

Number 5. Frame Food Bread.

This bread is made from ordinary white flour, to which an extract of bran is added. The extract is prepared by mechanical means from the bran, and consists of the following bodies :—

Water - - -	9·58
Carbo-hydrates - -	58·33
Proteids - -	21·40
Mineral matter - -	10·69
	100·00

The mineral matter is very rich in alkaline phosphates.

The extract may be added to the dough either as a powder or as a liquid, the object of the addition being to get a loaf having the same composition as whole-meal bread minus the bran particles.

The ratio of proteids to carbo-hydrate is as 1 is to 3·9, very much higher than in the case of fine white bread, and the bread contains 50 per cent. more mineral matter, consisting chiefly of phosphoric acid and potash.

Number 6. Germ Bread is manufactured from "germ" flour. Germ flour consists of about 75 per cent. of ordinary white flour, and 25 per cent. of the germ.

The germ being the embryo of the *Triticum* is rich in proteids, fat, and phosphates, and its retention in the flour adds materially to the nutritive value of the bread. The germ is specially treated in order to destroy the ferments and the bitter principle found in it. This bread is very rich in proteids, and contains far more fat and phosphates than ordinary bread. The ratio of proteids to carbo-hydrates is as 1 is to 3, slightly higher than the normal.

Number 7. Health Bread. This variety contains all parts of the wheat grain except the outer layers of the bran. The bread is thus free from irritating particles, while it retains the nutritious elements of the wheat. The ratio of nitrogenous matter to carbo-hydrate material is as 1 is to 3·6.

The process of preparation of the meal secures the rejection of the outer layers of the bran, consisting chiefly of woody fibre, while the inner layers containing the nutriment are retained and finely granulated.

I have only time to mention the existence of various malted breads, prepared by the addition of malt extract to the dough. Such breads are better flavoured and more digestible than ordinary bread, and there is very little risk of sourness. The malt favours quick fermentation, so that the souring germs are never allowed to develop in the dough, owing to the vigorous growth of the yeast and a minimum production of alcohol. The working is also cleaner, for potatoes need not be used when malt extract is employed.

Machine-made bread is coming more and more to the front, and rightly so. Such bread is surely to be preferred before hand-made bread, with the possible contingency of contamination from the bodies of the half naked operatives.

When it is impracticable to put down an extensive plant, hand-machines are used now in most bakeries, including such contrivances as kneaders, dough dividers, potato washing machines, flour blenders, &c.

The sanitary condition of bakehouses has of late years undergone much improvement, and it is rare indeed to find now-a-days dirty and unhealthy premises used for the purpose of bread-making.

I desire to record my sincere thanks to my assistant, Mr. D. J. Knightley, for the able manner in which he carried out my instructions while living on certain breads alone, and to my colleague Mr. C. H. Clarke, M.R.A.S., for confirming the analyses. I also wish to acknowledge my indebtedness to Dr. Frankland, F.R.S., for one of the analyses.

DISCUSSION.

Dr. Van Hamel Roos (Amsterdam) asked to what extent the mineral matter had been increased by adding lime water to the meal, and whether by lime water was meant a saturated solution of lime. He added, that, as editor of the "International Review of Adulterations," he was opposed to the adding of any foreign mineral matter to our food.

In reply to a question of Sir Roscoe as to whether copper salts were used in bakery in Holland, Dr. Van Hamel Roos answered that he never had found any in the meal and bread under his observation. Formerly it was met with in Amsterdam, but the adulteration was detected at once, as large crystals of copper sulphate were found in the bread. As to alum, he said that baking powders recommended as being used for improving bread on a large scale in England had been analysed by him and found to consist of alum. He thought these additions to meal and bread ought to be strictly prohibited.

Sir Charles Cameron said that it was undesirable to introduce indigestible and rough particles into the digestive organs. He had met many cases of suspected poisoning of oxen and sheep in which he was able to trace the real cause of death to the irritative action of undecorticated cotton cake, and even of other food stuffs. He thought the popular instinct was right when on the whole people preferred beautiful white bread, which they felt they could digest with comfort. Referring to Lawes' and Gilbert's experiments, Sir C. Cameron believed that a bread diet was more nitrogenous than a meat one, and therefore, that although white contained less nitrogen than brown bread, yet there was a sufficient amount of nitrogen in the former.

Mr. Cassal was glad that Dr. Van Hamel Roos had attended the Section, as he was editor-in chief of the very important "International Review of Adulterations," by means of which it might be hoped that in the near future united action would be taken by different countries for the suppression of adulteration. In regard to the use of sulphate of copper and alum in bread-making, he had always understood that the main object was to prevent fermentation from going too far when yeast was used, thus giving a badly coloured and acid bread; and also to enable damaged flours to be used by bakers.

Bromine and Iodine as Aërial Disinfectants; and on a new Method of Applying them.

BY

GERALD T. MOODY, D.Sc., and F. W. STREATFEILD.

The question of suitable aërial disinfectants for employment in hospitals, sick rooms, &c. is one of very great importance, and has not perhaps hitherto received the attention it deserves. Of the various substances employed, bromine has come largely to the front in recent years, and iodine has also been found to exert a considerable disinfecting action, although less than that of bromine weight for weight. Considerable difficulty has, however, been experienced in finding a suitable and convenient method of introducing these elements into the atmosphere. Various forms of lamps have been devised for the gradual volatilization of iodine and its diffusion through the air; and many have sought to effect the same purpose through the medium of the candle or night light. Whilst working in this direction, and with the endeavour to volatilize by means of a burning candle certain volatile brominated

organic derivatives of the aromatic series, it was discovered by one of the authors that *free* bromine vapour was evolved in quantity during the combustion of the candle. On extending the experiments to iodine derivatives a similar result was obtained. The authors therefore turned their attention to the preparation of a satisfactory bromine and iodine candle.

A modern candle is a very delicate piece of work, being the outcome of many years' experience and of much scientific and technical skill. Next to the proper refining of the fat or wax, the fabrication and chemical treatment of the wick are points of great importance, in order that the candle may burn with a bright flame, and free from cauliflower head. A very small quantity of a foreign body introduced into the substance of the candle causes a very marked effect on its combustion. Many of the disinfectants proposed for distribution by the aid of the candle caused it to burn very indifferently, and sometimes to be extinguished within an hour; or worse still, where it was sought to diffuse the vapour of certain balsamic or phenolic principles, the "disinfectant" itself underwent combustion and thus defeated the object in view. In the case where the free halogen was simply mixed with the combustible material of the candle, failure resulted from the escape of part of the halogen during storage, whilst the remainder gradually destroyed the material of the wick. After making numerous experiments the above-mentioned difficulties were overcome, and the authors succeeded in preparing candles and night-lights which do not undergo change on keeping, and by means of which any required quantity of the halogens bromine and iodine may be evolved with great exactness. This result has been accomplished by incorporating stable haloid organic compounds with the substance of the candle or night-night. Up to the present the most successful halogen compounds used have been dibromonaphthalene $C_{10}H_6Br_2$ and iodoform CHI_3. These substances are perfectly stable at ordinary temperatures, but when burnt under the conditions obtaining in a candle or night-light prepared from pure, well-pressed tallow, give rise to free bromine or iodine vapour respectively.

That the free halogen is evolved is shown by the odour produced; and its presence may be visibly demonstrated by the usual chemical method of holding at a short distance above the flame a piece of unsized paper moistened with a solution of starch and potassium iodide, which is rapidly turned blue.

The liberation of bromine and iodine during combustion may probably be explained on the assumption that the corresponding hydracids are formed in the first instance, and that these suffer decomposition at the temperature of the flame and in the presence of atmospheric oxygen into the free halogens and water, in accordance with the equations—

$$\text{(i.)}\quad 4HBr + O_2 = 2H_2O + 2Br_2$$

Hydrogen bromide and oxygen give water and bromine.

$$\text{(ii.)}\quad 4HI + O_2 = 2H_2O + 2I_2$$

Hydrogen iodide and oxygen give water and iodine.

The authors found that a very useful strength for general purposes is about 6 grains (0·3886 gram.) of either halogen compound in a 9-hour night-light; during combustion this will liberate bromine or iodine, the amount of which may be calculated as follows :—

The iodine night-light contains 6 grains of CHI_3, — C, $12 \times 1 = 12$; H, $1 \times 1 = 1$; I_3, $127 \times 3 = 381$; or, 394 grains of iodoform yield 381 grains of iodine; consequently 6 grains of iodoform in a night-light will give $\frac{381 \times 6}{394} = 5{\cdot}80$ grains of iodine liberated during the nine hours.

The bromine night-light contains 6 grains of $C_{10}H_6Br_2$; as before, — C_{10}, $12 \times 10 = 120$; H_6, $1 \times 6 = 6$; Br_2, $80 \times 2 = 160$; or the total 286 grains of dibromonaphthalene yield 160 grains of bromine, and consequently 6 grains of dibromonaphthalene will give 3·35 grains of bromine during nine hours.

By means of the above calculations it is easy to bring about the evolution of a stated quantity of either halogen, as during each hour's burning there will be evolved, of free iodine 0·64 grain, of free bromine 0·37 grain. By increasing or diminishing the quantity of the halogen compound mixed with the candle or night-light, any quantity of halogen, within reasonable limits, may be diffused.

The authors believe that the hygienic value of their discovery is very great, since it will make it possible for the vapour of bromine to be used as a household disinfectant in a safe and efficient manner and where it will be likely to do most good. It is especially for sanitary purposes that the bromine candle or night-lights are most likely to be useful, and there is no doubt they will prove of service for disinfecting closets, lavatories, and wherever sources of infection have to be guarded against. It must be understood that the bromine vapour evolved by the burning candle or night-light does not cause the slightest personal inconvenience in practice, candles containing about 6 grains of dibromonaphthalene having been burnt nightly by one of the authors during a period of two years. All the time the candle is burning the odour of bromine in the room is distinctly perceptible, but by no means disagreeable. Similar remarks apply to the iodine candle or night-light, which, besides being effective as a disinfectant and deodorant, has the advantage of possessing a therapeutical value in diseases of the throat, nose, and lungs.

DISCUSSION.

Mr. Cassal said that he had had occasion to examine these night-lights and could confirm the liberation of free iodine and bromine from them on burning, a fact which was in itself interesting; but he did not see that there was any special value attaching to such liberation for purposes of deodorisation or disinfection, and certainly not in regard to the latter.

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LONDON: Printed by EYRE and SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.

TRANSACTIONS

OF THE

Seventh International Congress of Hygiene and Demography.

LONDON, AUGUST 10TH–17TH, 1891.

Patron:—HER MAJESTY THE QUEEN.

President:—H.R.H. THE PRINCE OF WALES, K.G.

VOLUME VI.

SECTION VI.

ARCHITECTURE IN RELATION TO HYGIENE.

EDITED BY C. E. SHELLY, M.A., M.D.,
Assisted by the HONORARY SECRETARIES of the SECTION.

LONDON:
PRINTED BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

1892.

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SECTION VI.

ARCHITECTURE IN RELATION TO HYGIENE.

Tuesday, 11th August, 1891.

The PRESIDENT, Sir ARTHUR BLOMFIELD, in the Chair.

Presidential Address

BY

Sir ARTHUR W. BLOMFIELD, M.A., A.R.A., F.R.I.B.A.

After the inaugural ceremony of yesterday, and the admirable address in which the Prince of Wales gave so cordial a welcome to the visitors of this great International Congress, you will doubtless be anxious to begin the work which lies before us in the next four days with the least possible delay.

I shall not, therefore, detain you with a lengthy address in opening the business of this Section.

Its title, "Architecture in relation to Hygiene," is clear and precise, but it has no doubt occurred to many who have read it that it involves a question to which it is by no means easy to give a clear and precise answer, "What is the relation of architecture to hygiene?"

The difficulty of answering lies in the uncertainty as to the strict limits of the functions and duties of the architect.

One of the greatest of our English authorities on the subject—the late Mr. Fergusson—in the introduction to his well-known handbook, defines architecture to be "The art of ornamental and ornamented construction," and further on, speaking of the architect, he says, "It "would be well if, in most instances, he could delegate the mechanical "part of his task to the engineer, and so restrict himself entirely to "the artistic arrangement and ornamentation of his design."

If this view of architecture and of the legitimate duties of the architect were generally accepted as correct, the relation of architecture to hygiene would be reduced at once to something which is not always easy to trace or grasp, and which has never yet received the full amount of serious and careful attention that it well deserves. In that case most, if not all, of the valuable and interesting papers, which we are about to hear and discuss, would have to be addressed to some other more purely scientific section.

If, on the other hand, we take the more usual definition of architecture as "the art and science of building," its relations to the

science of hygiene at once become too varied and too complex to admit of clear and concise description. A vast field is at once opened out before us, in which it is often extremely hard, sometimes even impossible, to indicate with precision the line of demarcation between the domain of the architect and those of experts in other branches of science. As one out of many illustrations which might be cited of this difficulty, I may mention the wide and interesting subject of paving, which plays so important a part in the health, comfort, and well-being of communities. This large question seems to occupy a kind of neutral ground between the province of the architect and that of the civil engineer.

Many other similar instances might be given, but this one will be sufficient to show that the selection of subjects to be dealt with by this section must always be a matter of considerable difficulty.

Directly scientific considerations are admitted side by side with the purely æsthetic aspect of architecture, it becomes hard to name a subject for discussion at a Congress of Hygiene which would not be as suitable for an engineering, medical, or other scientific section as it is for that of architecture.

For this reason I venture to throw out the suggestion that for some future meeting of this Congress an extremely interesting and instructive paper might be written dealing exclusively with the points of contact between hygiene and the purely æsthetic side of architecture.

This branch of a great subject remains up to the present time practically almost untouched, perhaps partly from the fact that to many minds the attempt to establish any such relationship appears fanciful and unpractical. It is well known that one of the greatest of our English pioneers of sanitary science, the late Sir Edwin Chadwick, viewed the idea of any such connexion with disfavour, and even with anger; he seemed, indeed, to think that art and hygiene were not only unconnected, but even in some respects incompatible.

Notwithstanding this decided opinion of a great and deservedly respected authority, I do not think it would be difficult to show that such a connexion has, at any rate for certain minds and constitutions, a very real existence; neither would it be hard to prove that, although never perhaps closely followed up or fully worked out in all its bearings, the idea of some actual relation between beautiful and artistic surroundings and health, must have been present in the minds of many writers both ancient and modern. Time forbids me to do more than instance a very few examples.

I cannot refrain from giving one of great weight and venerable antiquity which I find in the third book of Plato's "Republic."

"Let our artists," he says, "be those who are gifted to discern "the true nature of beauty and grace; then will our youth dwell in "the land of health, amid fair sights and sounds; and beauty, the "effluence of fair words, will visit the eye and the ear, like a healthful "breeze from a purer region, and insensibly draw the soul, even in "childhood, into harmony with the beauty of reason."

Thus, it would appear, the great philosopher held that the finest productions of art, acting through the eye on the mind, exercise a distinct influence on bodily health; and if, as Emerson tells us, "Out "of Plato come all things that are still written and debated among "men of thought:" we may take this passage as a type of many similar thoughts scattered through the works of numberless authors from his day down to the present time. May not the same idea be traced in the much-quoted line of our own poet Keats, "A thing of beauty is a joy for ever"? But instances will not be found wanting of more direct reference to a real connexion between the beautiful in art, and especially in architecture, and the science of health, or hygiene.

Eight years ago the late E. W. Godwin read before a meeting at the Health Exhibition, then being held in London, an elaborate and masterly paper on "Dress in its relation to Health and Climate." In the course of a parallel which he draws in that paper between dress and architecture, he says: "Science and art must walk hand in hand, if "life is to be worth living. Beauty without health is incomplete. "Health can never be perfect for you so long as your eye is troubled "with ugliness." He goes on to point out that long habit will no doubt accustom most people to any degree of ugliness, so that the mind untrained in Art is seldom perhaps consciously troubled by it. But notwithstanding this apathy, a legitimate source of intellectual enjoyment is lost, and doubtless with it an appreciable element of health in its highest perfection; a loss which it is the business of the architect in some degree to supply by providing beautiful objects to satisfy and delight the eye, and by waging war with everything that is mean, ugly, and squalid.

At present, no doubt, large masses of people are still so habituated to these last characteristics in their every day surroundings that they scarcely feel a wish for anything better, just as they will get accustomed to evil smells, and to a vitiated atmosphere which they breathe quite unconscious of its insidious and deadly effects on their health.

But if education and culture continue to advance as they have done in the last fifty years, and habits of intelligent observation are fostered and encouraged, the eyes of the masses will every day become more sensitive and fastidious; the dreary and monotonous streets and badly designed buildings which a few years ago would have been passed unnoticed, will soon begin to exercise a distinctly depressing and disturbing influence on the mind, which cannot fail to have some ill-effect on the health, comfort, and general well-being of the community.

It is now, I believe, a recognised fact that certain colours, quite apart from the nature of the pigments or dyes which yield them, produce very decided effects, both on the mind and body when in certain conditions.

It is probable that the same is true of certain combinations of colours and even of forms in which the skill and taste of the artist must be paramount, and in which the aid of science, however necessary, can only be looked upon as subsidiary.

Valuable hints and suggestions bearing on this subject may be gathered from a lecture delivered many years ago at the Royal Institution by Cardinal Wiseman, entitled, "Points of contact between Science and Art." Also from an address delivered by Mr. Wyke Bayliss, President of the Royal Society of British Artists, "On Sanitary Reform in relation to the Fine Arts," at the Sanitary Congress held at Hastings in 1889.

As might naturally be expected from such a source, it teems with beautiful and poetical thoughts bearing on the subject. He shows how ruinous are dirt and disorder to the best interests of art, and how all artists must hail every onward step in sanitary reform as not only conducive to bodily health, but to the growth and progress of art. The whole cannot fail to be read with as much pleasure as profit, and anyone who desires to follow out the line of thought I have suggested in tracing a direct connexion between architecture as a fine art and hygiene, will do well to study this address with great care and attention. But the illustrations, arguments and advice made use of are directed more to the influence of sanitary reform on the growth and development of art than on the effect of art on health, a more obscure perhaps, but no less interesting subject, and the one I desire to see dealt with.

I have left until the last all mention of the only writer who, as far as I know, has ever made any serious attempt to deal systematically and in detail with this interesting subject.

Some years ago my friend Dr. B. W. Richardson, who stands in the foremost ranks of sanitary authorities, delivered a lecture upon it, which, I am afraid, is now out of print, and I have been unable to obtain a copy; but he has kindly furnished me with some information about it.

He tells me that the principal points he dwelt on were as follows:—

He began by showing that much prejudice has been excited against some of the best sanitary inventions and labours, because leading sanitarians have failed to consider artistic construction as part of sanitary construction; their whole minds have been absorbed in the useful, and they have permitted all that is ornamental to pass by as if good taste were disconnected from sanitation. He argued that this was a grand mistake; that ugliness was an offence to good health, and that beauty was an aid to the best health.

He showed that when mind and body are enfeebled by bad health, the introduction of disagreeable objects into the sick room or ward is painful and injurious to the occupants; whilst the presence of beautiful flowers, pictures, and designs is curative in its effects; a kind of mental tonic which gives tone also to the body. This thought led him to the consideration of the best forms for hospital wards having regard to the effect on the eye, and through the eye on mental and bodily health, and so with all the details of visible construction and of decoration.

Speaking of the dwelling house he maintained that no part ought to be excluded from the possession of architectural art, because it is the tendency of the human mind to let that which is disagreeable, plain, and ugly go without regard and accumulate dirt and disorder. Hence all

the offices of a house should have as much care bestowed on them as the living rooms to render them bright and cheerful, and to make cleanliness as obvious a necessity in one as the other. In this lecture Dr. Richardson made a great point of the treatment of floors, adverting particularly to the Ancient Roman mosaic floors which were not only beautiful works of art, but easily cleaned, and which by the well-known hypocaust system of warming diffused an equable and agreeable warmth through the room without draughts.

Other points especially dwelt upon were the treatment of roofs, and the introduction of artistic water fountains in different parts of the house.

No one could be found better qualified than Dr. Richardson to speak with authority on both the aesthetic and the scientific aspects of the question "What is the relation of Architecture to Hygiene;" but even when writing in the interests of art he is naturally first of all a man of scienc, and I should like to see the same subject dealt with by an architect from an artist's point of view.

Professor Fenger (Copenhagen) said that architects on the continent looked in many directions for instruction, but not so often to England as to continental countries; but the conviction is dawning upon them that in one respect England has taken a prominent part among the nations of Europe since the beginning of this century, namely, in sanitary house-building, as well as in the construction of separate wards in hospitals. Now they can scarcely build without being indebted to England for ideas. He concluded by proposing a vote of thanks to the President for his presence in the chair, and for his admirable address.

Mr. Charles Lucas (Paris) fit des remerciements à M. le Président pour son adresse sur la necessité de l'alliance de la Beauté et de l'Art, le souvenir donné aux regrettés Chadwick et Godwin.

The proposal was carried by acclamation.

On Open Spaces.

Read by the Earl of Meath.

[Prepared by Mrs. Basil Holmes, Hon. Sec. to the Metropolitan Public Gardens Association.]

If we could transport ourselves into the England of 200 years ago, or if we were even able to see what our great grandfathers looked upon, how hard it would be to recognise the sites of those places which are now so familiar to us. A great part of the land was common land, or lammas land, heaths, downs, forests, woods, moors, and village greens. But the increase of population, the concentration of the people into towns, the rapid growth of London and the manufacturing centres, these forces conjointly waged war against the open spaces, and gradually swallowed them up. Commons disappeared, fields and lanes became

streets and houses, village greens were encroached upon or thrown into the roadways, graveyards were used as sites for railway stations and public and private buildings of all sorts, and where the dead had peacefully slumbered was heard the noisy engine and the rattling train.

But the history of the desecration and loss of the open spaces round towns is too well known for me to dwell upon it here, and many will also be acquainted with the story of their revival, for it is but a recent one. Acts of Parliament have been passed to protect and regulate commons and greens, to preserve graveyards, to promote the acquisition of open spaces in and around towns, from the largest park to the smallest playground, and to provide for their maintenance. Philanthropic societies have started into existence, whose object it has been to carry out these Acts and stir up the public bodies to do so; and now, on all sides, the public mind is awakening to its need, and the public voice is beginning to ask for its satisfaction. But although something has been done to restore the lost breathing places, much, very much, still remains to be done; and what has been accomplished in the past in a scattered and unsystematic manner, will have to be done in the future, both thoroughly and systematically.

It appears to be a generally recognised and undisputed fact that, to restore enfeebled health or weakened animation, fresh air must be resorted to, *i.e.*, air that is not contaminated by the breath of human beings. We take the fainting person out of a building, we send the consumptive patient to the top of a Swiss pass or to the sea shore, and we carry the sick child from his crowded home in the city and place him in a country village. It is only necessary to glance through those statistics which show the death-rate in the manufacturing and closely inhabited towns as compared to the death-rate in the country or the suburbs, to learn the generally well known lesson that the health of the nation suffers in proportion to the degree that the individuals are crowded. Of course, I am aware that, notwithstanding the increase of population, there is a steady decrease in the death-rate over the United Kingdom, but this is due to improved drainage, warmer clothing, the great advance in medical knowledge, and a hundred other influences which are at work among the people; and, as this is now the case, who can say how robust the nation might have been by this time if the open character of the surroundings of the towns had been preserved.

It is strange to read of the time when the youth of London needed only to go to Moorfields (where Liverpool Street Station now stands) in order to stretch their limbs and sport in the free and open country; when Oxford Street was a country road; and the way to Islington, St. Giles, or Camberwell was through pleasant, flowery fields, by rural lanes and footpaths. Now, if we live in Islington and wish to see a meadow or a hedge, we must take the train and travel in it for some miles. Certainly there are Hyde Park, Regent's Park, and some 200 smaller recreation grounds in London, besides a few open spaces on its borders, but, invaluable as they are, they cannot supply the place of the open country, nor are they really adequate to meet the wants of the vast mass of people who live round them.

Granted that fresh air and open spaces are needed for the health of the inhabitants of our larger towns, we will briefly consider the two ways of satisfying this need, namely:—1st. A systematic acquisition and preservation of land for public recreation, in connexion with the towns and in relation to their growth. 2nd. Increased facilities for taking people from the towns into the country.

In the towns themselves the governing bodies—the councils—should lay down and should carry out some such rule as the following:—That public recreation grounds should be provided in each parish, in proportion to the number of its inhabitants.

This would mean that there should be a fixed minimum of open space for a certain number of the population. Here and there the minimum would be exceeded, and so much the better for the people, but it should always be reached, either by securing existing open spaces for the public for ever, or by acquiring new ones, and this, if need be, by pulling down houses for the purpose. And for the information of those who are not well acquainted with the question of acquiring open spaces, I would mention that much may be done in the towns by securing and throwing open enclosed and deserted squares, disused graveyards, the remnants of village greens (where such have become merged into the towns), vacant plots of railway land, abandoned wharves, market-places, &c., &c. The Open Spaces Act of 1877, amended in 1881, 1887, and 1890; the Disused Burial Grounds Act of 1884, with its amendments; and other measures, give all the power that is needed to local bodies to carry out these improvements. The Metropolitan Public Gardens Association, which has been at work in London since the close of the year 1882, has laid out, or assisted to lay out, 65 gardens and playgrounds for the use of the public; has given grants of seats for 31 other sites, either streets or open spaces; has granted money towards the formation and upkeep of 23 public gymnasia; has secured the opening of 166 playgrounds belonging to the London School Board (on Saturdays); and the laying out and throwing open of 19 recreation grounds; has planted trees, and given grants for tree-planting in 37 thoroughfares and other sites; has opposed encroachments on 18 disused burial grounds, commons, and open spaces; and has in other ways assisted in the preservation and formation of very many useful recreation grounds. What has been done in London (and it is very little compared to what needs doing) can be done in the other large towns; there is the same opportunity for improving them by bringing green grass, bright flowers, and shady trees into the dingy and monotonous streets.

It may be said that if you increase suburban life you do as much harm as by enlarging a town. But, certainly, if you take the wives and children belonging to a community away from the city and into the suburbs, you are doing them good from an hygienic point of view. The husbands and fathers will have the advantage of spending their nights and their Sundays in purer air, and the disadvantage of, perhaps, journeys in a train twice or more on every week day. But London and the large towns *will* increase, and the only question to be settled is—

Are they to increase from outside inwards, or from inside outwards? These two diagrams will illustrate, in a rough manner, what I mean. The size of the central circles (denoting the towns) is the same. The size of each excrescence, and their number (denoting the suburbs), is the same. The amount of open space enclosed in each dotted circle is also the same, but its distribution is different.

In Fig. 1 the largest mass of new houses is next to the old centre, whereas the smallest group of new houses adjoins the largest plot of open space. In Fig. 2, on the contrary, a larger area of open space is brought close to the old mass of buildings, and the greatest number of new buildings are nearest to the open country. There are, perhaps, advantages in either system; but the advantages in the second, from a healthful point of view, if not from an artistic one, outbalance, in my opinion, those of the first. It may be said, however, that the plans are too fanciful to be of any use; that suburbs always grow in accordance with local need and local possibilities; and that a town built in a pattern, and only allowed to grow in a pattern, would be impossible and undesirable. But I am speaking theoretically, and I wish my theory to be illustrated in a purely systematic way. Fig. 2, if carried out, would involve a cessation of building immediately adjoining the original centre, and this is what is most needed. In other words, a town that has reached a certain size should grow no more, except from centres at a given distance outside. I am not speaking of a plan suitable for time and eternity, or to be carried out by generations far ahead of our own. They will need other and much more far-reaching reforms in building, if the population continues steadily to increase. I am speaking of something that is needed at the present time, and of a plan that might now be adopted in several of the larger towns in England. To take the metropolis as an example:—It is not so likely to hurt London that Wimbledon or Tottenham should grow to great proportions; what does hurt London is, that all the fields of Fulham and Deptford are being covered with houses. It is the increase at the centre that is so detrimental—the gradual annihilation of the remaining open space which is close to, or forms part of, the towns. The increase should be in the suburbs of a town, or, rather in a certain number of them whose centres are beyond a given distance from the city. This need not produce a monotonous sameness. There would soon be characteristic differences in the various suburban districts. There would be the aristocratic suburb, joined to the town by a handsome drive and a rotten row; the commercial suburb, with its service of city trains running every hour, half-hour, or minute, if need be; the artistic suburb, selectly free from the incursions of the railway director, where the linnet and the lily would flourish undisturbed; the domestic suburb, arranged for schools and kindergartens, nurses and perambulators; the cheap suburb, very noisy, and connected with the city by tram-lines and subways; and there might be, but we should hope that there would not be, the cheap and nasty suburb, complete in itself, in its dirt and in its degradation. But each, if not allowed to grow at the city end, but only at the end furthest removed from the town, would share alike in

possessing vast strips of open land for the recreation of the people and their children.

In the towns themselves there should be every effort made to have beautiful streets, with trees and seats in them, and beds of flowers, instead of neglected and dirty corners, and creepers planted on bare walls. Every disused graveyard and deserted enclosure should become a bright garden, and every plot of unused land be made into a children's playground or an outdoor café.

If the preservation of open spaces were properly taken in hand and systematically carried out, there would not be so much need as there is now for increasing the facilities for taking people from the towns into the country. But still it will always be of great advantage, both to young and old, to see new places and breathe different air; to visit the seaside and the rural country. The railway companies have done much of late years to render this possible to a greater number by issuing cheap "fortnightly" tickets for the seaside, &c., &c., and there is more than one useful society at work giving country holidays to city children, and sending the tired seamstress and overworked clerk to breathe the sea air; besides numberless private people who are doing their best to supply this need by throwing open their own country houses, or paying for the holidays of those who are less blest than they are with this world's goods. This is a question which is not so easily dealt with officially; it is one which, although very important, must be left more or less to be settled by the railway companies and by the people themselves. Something may be done to teach the inhabitants of the towns how best to make use of their holidays, especially the bank-holidays. But, after all, they will please themselves, and some will go to Epping Forest, while others will sit in the nearest tavern and drink, and drink, and drink; and, amongst those who are in Epping Forest, there will be some who feast their eyes on the beautiful trees and tender grass, while others will care for little beyond the ginger-beer and the sticky sweets.

It must always be remembered, in speaking of the open space question, that it is not one which, having been fully dealt with, may now be put aside as settled. On the contrary, the need of providing open spaces increases daily, while the difficulty of finding them does not diminish. It would be a great boon if a new Building Act were passed forcing builders to provide recreation grounds, or to reserve breathing spaces for a fixed number of new houses. So long as the population grows, so long will new public and domestic buildings be erected, and so long will there have to be voluntary action, if there is not State-directed action, to preserve or to provide open spaces for those who increase and multiply in the land. One word more. The work must be done well. It is better to have small recreation grounds, preserving their rural foliage and beauty, than to have large parks, stiff, flat, bare, and uninteresting. We want large and small open spaces, but natural ones; country left in the town so that the townsfolk may not forget the country.

DISCUSSION.

Mr. Rogers Field wished to suggest that all open spaces should be connected by boulevards or park roads. He was not aware that this had been done already in Chicago. He remembered that in his very early days there was an opportunity of making a magnificent boulevard between Regent's Park and Hampstead Heath. The idea had been suggested by the late Professor Cochrane in about 1851, and the plan was published in the *Builder* newspaper. The outbreak of the Crimean War had interfered with the carrying out of the plan. Then, between Primrose Hill and Hampstead Heath there was a fine avenue of trees. This avenue, which was still in existence—Belsize Avenue—could have been obtained at an exceedingly reasonable rate, and plans had been made showing how that avenue could be turned into a magnificent drive from Primrose Hill to Hampstead Heath. Now, however, unfortunately, the whole space was built over, and there was no means of connecting these two open spaces. This was a question to which the greatest attention should be paid. He happened to know the case he had cited intimately, but no doubt there were other cases round London where building was going on, and where the connexion between open spaces should be attended to.

Mr. H. H. Collins said that in this matter, as in so many others, Queen Elizabeth was right when she endeavoured to put a stop to the building of more houses in London. The builders could not be expected to help in the multiplication of open spaces, but the owners of land might be induced to do it because it could be shown to be in their own interests. They could not get the necessary means from the ratepayers, and he would rather depend upon philanthropy than upon State aid. They could not prevent landlords from selling their land, but they could be shown, as had been seen in the very district where Mr. Rogers Field lived at Fitzjohn's avenue, that an apparent sacrifice of land often increased the value of it.

Dr. J. F. J. Sykes (one of the Hon. Secretaries to the Section) said: A great deal of gratitude we owed to the ignorance—or possibly enlightenment—of those people who, by using as burial grounds large open places now in the middle of London, had kept the same from the grasp of the builder. In all probability posterity, if we took to cremation, would have no occasion to bless us from a similar point of view.

Mr. B. Johnson (of the Poplar Board of Works) thought that, in order to prevent land being so built upon that nothing could be seen of the natural beauties of a locality, power should be given to local authorities to prevent more than a certain number of houses being put upon a plot. The necessity of such restraining powers being given was well illustrated in the Isle of Dogs, where men were allowed to go down 8 ft. or 9 ft. underground with the lower floors of houses, and where many families were living literally underground. Until county councils and local authorities had such powers they would never be able to prevent land being covered by houses built like tea-chests, nor to stop jerry building.

Dr. Engel R. L. Gould, of the U.S. Department of Labour, Washington, cited statistics which showed that London held the twentieth position with regard to its open spaces, measured in terms of the number of inhabitants per acre. Vienna had a population of 473 per acre, Paris 495, Brussels 637, while London had 694. The Earl of Meath appeared to be in favour of small instead of large open spaces. He found that London took higher rank when the larger parks were left out of the reckoning. Without

the great parks, London had a population of 909 per acre; but Philadelphia, which had a population of over 1,000,000, and had only 340 per acre on the average, had 17,649 per acre when its greatest park was left out, and Vienna would have 3,300 per acre with one great park left out.

Hygienische Grundsätze für die Erweiterung und den inneren Ausbau der Städte.

VON

J. Stübben, Stadtbaurath in Köln.

A.—Allgemeine Aufgabe.—1. Die Erweiterung einer Stadt darf nicht der freien Privatthätigkeit allein überlassen werden, sondern ist durch amtliche Maassnahmen der Gemeinde und des Staates zu regeln; das gleiche gilt für den Ausbau einer Stadt im Innern. 2. Zu den wichtigsten Obliegenheiten, welche Gemeinde und Staat hierbei zu erfüllen haben, gehört der Schutz des gesunden Wohnens und des gesunden Aufenthalts in der Stadt.

B.—Hygienische Erfordernisse. — Gesundes Wohnen und gesunder Aufenthalt erfordern: 1. Genügende Breite der Strassen; gesundheitlich zweckmässige Herstellung und Ausstattung der Strassen und freien Plätze. 2. Oeffentliche Pflanzungen. 3. Reinhaltung des Untergrundes, des Wassers und der Luft. 4. Wasserversorgungs-, Beleuchtungs- und Verkehrsanlagen. 5. Herstellung zweckmässiger Baugrundstücke in ausreichender Zahl und passender Grösse. 6. Gesundheitlich gute Anordnung und Einrichtung der Gebäude, Arbeitsstätten und Wohnungen.

C.—Amtliche Maassnahmen. — Um diese Erfordernisse zu erreichen, sind folgende positiven und negativen Maassnahmen der Gemeinde und des Staates zu ergreifen: *a. Positive Maassnahmen.*— 1. Aufstellung eines zweckmässigen Bebauungsplanes für die Stadterweiterung, welcher sich erstreckt auf alle im Anbau begriffenen und zum Anbau in den nächsten 20 Jahren bestimmten Theile der städtischen Umgebung; Aufstellung eines zweckmässigen Bebauungsplanes für die Verbesserung der alten Stadttheile. 2. Aufstellung einheitlicher Entwürfe für Entwässerung, Abfuhr, Schutz gegen Hochwasser, Wasserversorgung, Beleuchtung und Verkehrsanlagen. 3. Ausführung der Strassen, Plätzen, und Pflanzungen, der Siele und öffentlichen Bedürfnissanstalten, des Hochwasserschutzes, der Wasserversorgungs-, Beleuchtungs- und Verkehrs-Einrichtungen *seitens der Gemeinde, insoweit Privatunternehmungen nicht ausreichen*, um einen angemessenen Vorrath an bebauungsfähigen und zur Bebauung bereit gestellten Grundstücken stets zu sichern und dadurch den Ausschreitungen des Baugrund- und Miethwuchers vorzubeugen. 4. Umlegung und Zusammenlegung der nach Lage, Gestalt und Grösse zur Bebauung ungeeigneten

Landparzellen in bebauungsfähige Baugrundstücke. 5. Begünstigung des Anbaues von Wohngebäuden für die unbemittelten Volksklassen. 6. Erlass gesundheitspolizeilicher Bauvorschriften für die zu errichtenden Gebäude, sowohl über die Beziehungen zwischen den Gebäuden, der Strasse und dem Grundstück, (offene Bauweise, Vorgärten Gebäudehöhe, Hofräume) als über die inneren baulichen Einrichtungen (Bauordnung). *b. Negative Maassnahmen.*—1. Verbot von Bauten, welche gegen den Bebauungsplan verstossen. 2. Verbot des Anbaues an unfertige Strassen. 3. Verbot, in bestimmten Stadttheilen gewerbliche Anstalten zu errichten, welche durch Ausdünstungen ,Rauch oder Lärm die Gesundheit der Bewohner oder die Annehmlichkeit des Wohnens beeinträchtigen. 4. Verbot des Bewohnens gesundheitsschädlicher Räume. 5. Verbot der Ueberfüllung. 6. Niederlegung gesundheitsschädlicher Gebäude und Stadttheile.

D.—Gesetzgebung.—Die Gesetzgebung des Staates ist so zu ergänzen, dass sie die Ausführung der angegebenen positiven und negativen Maassnahmen ermöglicht und erleichtert. Es bedarf insbesondere folgender Gesetze: 1. Gesetz über die Feststellung von Baufluchtlinien und Bebauungsplänen. 2. Gesetz über die Enteignung des Strassenlandes, der bebauungsunfähigen Restgrundstücke neben der Strasse, der gesundheitschädlichen Gebäude und Stadttheile (Zonen-Enteignung). 3. Gesetz über die Umlegung und Zusammenlegung städtischer Landparzellen, welche nach Lage, Gestalt und Grösse zur Bebauung ungeeignet sind. 4. Gesetz über die örtliche Beschränkung der Einrichtung lästiger Gewerbebetriebe. 5. Gesetz über das gesundheitsgemässe Bauen. 6. Gesetz über das gesundheitsgemässe Wohnen.

A. *Allgemeine Aufgabe.*—Jedes Eingreifen der staatlichen oder communalen Obrigkeit in die freie Thätigkeit des Bürgers wird von diesem unter Umständen unangenehm empfunden. Dennoch hat kein Kulturvolk, welche Regierungsform es auch besass, das Eingreifen der obrigkeitlichen Gewalt in die bürgerliche Thätigkeit entbehren können. Und bei unserer heutigen kulturellen Entwickelung ist erst recht die Unterordnung des Einzelnen unter das Allgemeinwohl von nöthen. Salus publica suprema lex.

Je mehr wir die Richtigkeit dieses Satzes anerkennen, desto wichtiger ist es auf der anderen Seite, das Eingreifen des Staates und der Gemeinde in denjenigen Dingen zu vermeiden, wo die Privatthätigkeit, ohne Missstände zu erzeugen, ausreicht. Solche Missstände aber sind durch die freie Privatthätigkeit bei der Erweiterung der Städte vielfach entstanden.

Es sind neue Strassen und Stadtviertel geschaffen worden ohne genügende Verkehrsverbindung mit der alten Stadt und mit anderen Stadtvierteln: nachträgliche Strassendurchbrüche für öffentliche Rechnung waren die Folge. Strassen ohne ausreichende Breite und mit ungeeigneten Steigungen mussten nachträglich verändert werden. Ganzen Bezirken fehlte olge unzweckmässiger Höhenanordnung die Entwässerung; Senkgruben und Schlingfelder verdarben den Untergrund, das Wasser und die Luft; die öffentliche Gesundheit litt Noth. Es ist nicht etwa bloss Mangel an gutem Willen oder an

technischer Befähigung, wodurch die blosse Privatthätigkeit zu solchen Missständen führt, sondern es liegt in höherem Grade daran, dass weder der Einzelne noch eine private Verbindung Einzelner imstande oder berufen ist, die Bedürfnisse der Allgemeinheit inbezug auf Verkehr und öffentliche Gesundheit zu überschauen, noch weniger aber die Macht hat, diese Bedürfnisse unter Besiegung der entgegenstehenden Hindernisse zu befriedigen. Dies gilt sowohl für die äussere Erweiterung als für den inneren Ausbau einer in der Entwickelung begriffenen Stadt. Die Regelung und Unterstützung der Privatthätigkeit durch amtliche Maassnahmen der Gemeinde und des Staates ist desshalb unentbehrlich.

Thatsächlich bestehen in allen Kulturstaaten Gesetze, auf Grund deren die Gemeinde und der Staat in die Erweiterung und den Ausbau der Stadt theils positiv theils negativ eingreifen können und eingreifen. In den meisten Staaten aber ist diese Gesetzgebung unvollkommen, oder die Anwendung der Gesetze lässt zu wünschen übrig. Desshalb verlohnt es sich wohl, den Gegenstand auf einem internationalen Kongress zu besprechen.

Unser Kongress beabsichtigt sich zwar nur mit hygienischen und demographischen Fragen zu beschäftigen. Aber eine der wichtigsten Aufgaben, welche beim Städtebau zu erfüllen sind, liegt gerade auf hygienischem Gebiete: es ist der Schutz des gesunden Wohnens und des gesunden Aufenthalts in der Stadt.

Von welcher Bedeutung dieser Schutz ist, das zeigt uns der Vergleich der städtischen Bevölkerungszahl mit der ländlichen und ein Blick auf das rasche Anwachsen der Stadtbevölkerung.

Der Antheil der städtischen Bevölkerung, mit der wir es hier zu thun haben, an der Gesammtbevölkerung betrug in den angegebenen Jahren im Deutschen Reich (1885) 43·7%, in Preussen allein (1890) 39·3%, in Oesterreich ohne Ungarn (1880) 38·4%, in Italien (1881) 59·7%, in Frankreich (1886) 36%, in England ohne Schottland und Irland (1871) 61·7%, in Russland ohne Finland (1885) 12·9%. Die beiden zuletzt genannten Staaten zeigen die grösste und die geringste Entwickelung der Städte. Seit den angegebenen Jahren ist überall, wie vorher, die städtische Bevölkerung rascher angewachsen als die ländliche. Während z. B. die Bevölkerung Deutschlands jährlich um wenig mehr als 1% zunimmt, beträgt die Volksvermehrung der meisten deutschen Städte 2 bis 4%; in kleineren Industriestädten hat man ein noch schnelleres Wachsthum beobachtet. Ebenso wächst die Bewohnerzahl der meisten französischen Städte jährlich um 0·5 bis 2%, obwohl die Bevölkerung des ganzen Landes nur um etwa 0·15% jährlich zunimmt. Ausführlichere Zahlen enthält die nachfolgende Tabelle über das jährliche Wachsthum einer Reihe von Grossstädten in den angegebenen Zeiträumen:—

JÄHRLICHE VOLKSZUNAHME EUROPÄISCHER GROSSSTÄDTE.

Deutschland.			
Berlin 1880–85	-	-	3·2 %
„ 1885–90	-	-	4·0 „
Hamburg 1880–85		-	2·0 „
Breslau 1880–85	-	-	1·9 %
„ 1885–90		-	2·9 „
München 1880–85	-	-	2·6 „
Leipzig 1880–85	-	-	2·7 „

Köln 1880–85	2·2 %
„ 1885–90	3·5 „
Dresden 1880–85	2·2 „
Magdeburg 1880–85	3·2 „
„ 1885–90	5·4 „
Frankfurt a/M. 1880–85	2·4 „
„ 1885–90	3·3 „
Hannover 1880–85	2·6 „
„ 1885–90	3·3 „
Königsberg 1880–85	1·4 „
„ 1885–90	1·4 „
Oesterreich-Ungarn.	
Wien 1880–90	2·0 „
Budapest 1880–90	3·1 „
Frankreich.	
Paris 1872–76	1·8 „
„ 1876–81	3·6 „
„ 1881–86	0·7 „
„ 1872–86	2·0 „
Lille 1881–86	1·4 „
Lyon 1881–86	1·2 „
Bordeaux 1881–86	1·5 „
Marseille 1881–86	0·8 „
Nantes 1881–86	0·4 %
St. Etienne 1881–86	−0·4 „ (*Abnahme.*)
England.	
London 1861–71	1·5 „
Liverpool 1861–71	1·6 „
Manchester 1861–71	0·8 „
Bradford 1861–71	3·1 „
Leeds 1861–71	2·2 „
Sheffield 1861–71	2·6 „
Holland.	
Amsterdam 1879–87	2·6 „
Rotterdam 1879–87	3·4 „
Haag 1879–87	3·4 „
Schweiz.	
Zürich 1880–88	2·3 „
Basel 1880–88	2·1 „
Dänemark.	
Kopenhagen 1885–90	2·2 „
Russland.	
St. Petersburg 1881–88	−1·2 „ (*Abnahme.*)

Nur aus zwei Städten, St. Etienne und St. Petersburg, wird hiernach eine Bevölkerungsabnahme berichtet; in allen anderen übersteigt die Zunahme die Volkszunahme des Landes überhaupt. Aus England fehlen mir leider die Zahlen aus den beiden letzten Jahrzehnten. Man wird annehmen dürfen, dass von den 350 Millionen Einwohnern Europas zur Zeit mindestens 100 Millionen in Städten wohnen.

Kuichling in Rochester (N.Y.) hat durch vergleichende Untersuchung einer grossen Reihe von amerikanischen, deutschen und englischen Städten die nachfolgende mittlere Tabelle für die städtische Bevölkerungszunahme berechnet:—

Tabelle der durchschnittlichen Jahreszunahme der Bevölkerung in Prozenten.

Bevölkerungszahl.	100,000	125,000	150,000	175,000	200,000	225,000	250,000
Amerikanische Städte	4·65	4·30	4·04	3·79	3·55	3·36	3·20
Deutsche Städte	3·57	3·33	3·10	2·87	2·66	2·46	2·26
Englische Städte	3·16	2·99	2·83	2·67	2·52	2·38	2·26

Bevölkerungszahl.	275,000	300,000	325,000	350,000	375,000	400,000
Amerikanische Städte	3·04	2·92	2·80	2·70	—	—
Deutsche Städte	2·09	1·93	—	—	—	—
Englische Städte	2·13	2·00	1·92	1·84	1·75	1·68

Die amerikanischen Städte wachsen hiernach am schnellsten, und der Prozentsatz der Vermehrung nimmt im Allgemeinen ab mit der Bewohnerzahl. Die Abweichungen von dieser Regel sind indess besonders in Deutschland zahlreich. In den sieben grössten deutschen Städten vermehrte sich die Bevölkerung während eines Jahrhunderts in Berlin um das 8fache, in Hamburg um das 5fache, in Breslau um das 5fache, in München um das 7fache, in Leipzig um das 9fache, in Köln um das 7fache, in Dresden um das 6fache.

Man denke sich, dass in einer Stadt von 100,000 Einwohnern es durch hygienische Massnahmen gelingt, die jährliche Sterblichkeit dauernd um nur 1 auf 1,000 zu vermindern, so bedeutet dies schon die Rettung von 100 Menschenleben. Statistische Nachweisungen, dass die Sterblichkeitsziffer einer Stadt infolge einer Reihe von hygienischer Massregeln um 10 auf 1,000 gesunken ist, sind aber keine Seltenheit. Das beste Kapital jedoch, womit die Welt arbeitet, ist das Menschenleben. Daraus folgt, welche riesige volkswirthschaftliche Wohlthat wir der Menschheit zufügen, wenn wir unsere Städte, in deren Mauern jährlich allein in Europa ein Zuwachs von etwa 2 Millionen Menschen Wohnung und Erwerb sucht, so anlegen, dass von vornherein die Sterblichkeitsziffer als eine möglichst geringe sich ergiebt.

B. *Hygienische Erfordernisse.*—Die hygienischen Erfordernisse, welche zu befriedigen sind, um gesundes Wohnen und gesunden Aufenthalt in einer Stadt zu erzielen, sind mannigfacher Art. Sie beziehen sich auf die Anlage der Strassen, freien Plätze und Pflanzungen; auf die Ausstattung dieser Anlagen mit Ent- und Bewässerungs-, sowie Beleuchtungseinrichtungen; auf die Schaffung bequemer und billiger Verkehrsmittel; auf die Bereitstellung passender Baugrundstücke zur Ansiedelung, sowie auf den Erlass einer hygienisch guten Bauordnung.

Wie breit und wie gerichtet die *Strassen* sein sollen, das ist auf dem letzten hygienischen Kongress zu Wien eingehend berathen worden, wenn auch kaum mit praktisch brauchbaren Ergebnissen. So lange man die Forderung darauf beschränkt, dass das Himmelslicht in alle Wohnräume ausreichend eintreten und zu diesem Zwecke die Strassenbreite wenigstens gleich der $1\frac{1}{2}$fachen Häuserhöhe sein soll, wird sie allmälig vielleicht erfüllbar werden, obwohl zur Zeit die einfache Häuserhöhe als Strassenbreite auch bei Neuanlagen noch keineswegs hat allgemein durchgeführt werden können. Wenn man aber die Forderung der Besonnung der Strassenbreite zu Grunde legt und unter dem 50sten Breitegrad Meridionalstrassen von 47^{m}, Aequatorialstrassen von 66^{m} Breite beansprucht, so verlangt man Unmögliches. Man wird in der Regel schon mit der einfachen Gebäudehöhe als Strassenbreite zufrieden sein müssen, daneben aber für eine ähnlich günstige, freie Stellung der Gebäude im Inneren der Blöcke zu sorgen haben. Als beste Strassenrichtung, insofern es sich um die Besonnung der Gebäudefronten handelt, hat *Gruber* entgegen den Ermittelungen von Vogt und Clément die zu den Himmelsrichtungen diagonalen Linien festgestellt. Dies ist um so mehr zutreffend, als mit den Häuserfronten zugleich auch alle Rück- und Seitenfronten diagonal zu liegen pflegen, während

der verhältnissmässig günstigen Ostwestlage einer Hauptfront die sehr ungünstige Nordlage der einen Seitenfront entspricht.

Bei der Stadterweiterung von Köln, welche ich die Ehre hatte zu entwerfen und auszuführen, hat, weil für die Strassenrichtungen die Lage der neuen Festungsthore zumeist bestimmend war, der hygienische Gesichtspunkt bei der Richtungswahl eine nur geringe Rolle spielen können. Dennoch ist die Diagonale zu den Hauptthimmelsrichtungen vorherrschend. Die Breitenbestimmung bedurfte gewisser Uebergänge aus der sehr eng gebauten Altstadt in das neue Bebauungsfeld von 10^{m} auf 14^{m}. Letzteres ist die Minimalbreite neustädtischer Strassen; die Breite wächst von 2 zu 2^{m} bis auf 70^{m}. Die Bauordnung erlaubt leider, dass die Häuserhöhe die Strassenbreite um 3^{m} übersteigen darf. Die höchste zulässige Höhe beträgt 20^{m}.

Dass bei Feststellung des Bebauungsplanes ein angemessener Prozentsatz des Geländes für Strassen, freie Plätze und öffentliche Anlagen in Anspruch zu nehmen ist, versteht sich von selbst. Ein geringster zulässiger Prozentsatz lässt sich aber nicht, wie es oft versucht worden ist, festsetzen. Denn bei offener Villen-Bebauung mit grossen Gärten können beispielsweise 15% Strassenflächen genügen, während bei geschlossenen fünfstöckigen Reihenhäusern, geringen Hofräumen und kleinen Blöcken 45% Strassenflächen zu wenig sein können. Ein Durchschnittsverhältniss ist 35%.

Zur Herstellung der Strassendämme dürfen nur Bodenarten verwendet werden, welche frei von gesundheitschädlichen Bestandtheilen sind. Vegetabilische und animalische Abfälle sind im Strassenkörper unzulässig. Dasselbe gilt für die etwaige Aufhöhung der Baugrundstücke. Vorhandene Faulstoffe sind zu entfernen, bevor man die Aufhöhung der Strassen, Plätze und Baugrundstücke beginnt. Auf Grund von Erfahrungsbeispielen vermuthe ich, dass Siechthum und Tod in mehr Fällen die Folge des schlechten Untergrundes sind, als sich nachweisen lässt.

Diejenigen Flächen der Strassen und öffentlichen Plätze, welche dem Verkehr ohne Nachtheil entzogen werden können, sind zu bepflanzen, mit Baumreihen, mit Rasen, Strauchwerk und Landschaftsgärten.

Ausser den Baumreihen auf Strassen, welche nur bei Strassenbreiten von mehr als 20^{m} lebensfähig sind, den Rasenbeeten und Gartenanlagen auf freien Plätzen und sehr breiten Strassen,* sind zwei Arten *öffentlicher Pflanzungen* eine hygienische Nothwendigkeit, nämlich 1. öffentliche Spielplätze für die Jugend, 2. öffentliche Gärten für die Erholung der Bürgerschaft. Spielplätze (Recreation-places) sind meines Wissens in England am meisten verbreitet: im Jahre 1889 soll London 28, Manchester 11, Birmingham 9, Bradford 7 bepflanzte Plätze dieser Art besessen haben, welche ausschliesslich dem Kinderspiel gewidmet waren. Berlin, Leipzig, Hamburg, Köln sind diesen englischen Beispielen gefolgt.

Einer grösseren öffentlichen Parkanlage, eines "Stadtgartens," sollte keine Stadt von 20,000 Einwohnern entbehren. Je grösser die Stadt,

* Vergl. *Stübben*, Städtebau, 5. Abschnitt, Darmstadt bei Bergsträsser, 1890.

um so geräumiger der Stadtgarten, besonders dann, wenn wenig sonstige bepflanzte Spazierwege, wie alte Wallpromenaden u. dergl., zur Verfügung stehen. Bei der Einwohnerzahl von 50,000 oder 60,000 etwa tritt der grösseren Entfernungen wegen die Nothwendigkeit des zweiten Stadtgartens ein. Grossstädte und besonders Millionenstädte bedürfen einer grösseren Zahl von öffentlichen Parkanlagen, um allen Wohnungen den Genuss des Pflanzenlebens in mässiger Entfernung zu ermöglichen. Nimmt man auf 50,000 Einwohner einen Park von 10^{ha} Grösse an, so findet sich bei einer Wohnungsdichtigkeit von 250 Personen pro Hektar das Verhältniss der Parkfläche zur Stadtfläche wie 1 : 20. Beträgt das Verhältniss der bepflanzten Strassen und freien Plätze zum Weichbilde ebenfalls 1 : 20, so erhält man als wünschenswerthe Verhältnisszahl, dass wenigstens $\frac{1}{10}$ des bebauten städtischen Weichbildes öffentlich bepflanzt sein möge.

Die englischen und französischen Städte sind, wenn auch nicht alle das angegebene Verhältniss erreichen werden, in dieser Hinsicht den deutschen und italienischen Städten überlegen. In England und Italien überwiegt die Parkanlage, in Frankreich und Deutschland die Strassenbepflanzung. Beides sollte gleichmässig gepflegt werden. In der Stadterweiterung von Köln, welche ein Gelände von 452^{ha} bedeckt, haben wir drei öffentliche Parkanlagen von zusammen 25^{ha}, gärtnerisch geschmückte freie Plätze von 8^{ha}, Gartenanlagen auf der grossen 32 bis 100^{m} breiten Ringstrasse von 8^{ha}, endlich mit Baumreihen besetzte Strassen von 12^{ha} Flächeninhalt, zusammen also 53^{ha} Pflanzungen, was $11 \cdot 7\%$ des bebauten Weichbildes beträgt.

Besonders reizvoll und hygienisch vortheilhaft sind diejenigen Parkpflanzungen, welche von den Hausgrundstücken unmittelbar zugänglich sind, wie der Parc Monceau zu Paris oder der Blasewitzer Park bei Dresden, auch diejenigen geschlossenen Squares, welche nach englischer Sitte zwar von Strassen umgeben sind, aber nur von den Umwohnern benutzt werden dürfen.

Zur Reinhaltung des Untergrundes, des Wassers und der Luft bedarf es ferner der geordneten Entwässerung, des Schutzes gegen Hochwasser, der Reinhaltung natürlicher Gewässer, der Beschränkung luftverderbender Gewerbebetriebe. Als beste Stadtentwässerung hat sich die unterirdische Kanalisation nach dem *Schwemmsystem* erwiesen, welche mangels grosser natürlicher Flüsse mit Rieselfeldern oder mechanisch-chemischer Klärung zu verbinden ist. Selbst für Köln wird seitens der Königlichen Staatsregierung eine künstliche Klärung der Kanalwässer, bevor sie in den grossen Rheinstrom münden, verlangt, eine mit gewaltigen Kosten verknüpfte Forderung, welche nach dem Stande der Wissenschaft und Pettenkofers neuesten Untersuchungen kaum gerechtfertigt erscheint.

Oeffentliche Wasserversorgung und *öffentliche Beleuchtung* sind in unseren eng bewohnten Städten, wo nicht mehr jede Haushaltung einen zuverlässigen Brunnen hat und nicht mehr Jeder auf dunkeler Strasse seine eigene Laterne tragen kann, eine Nothwendigkeit für die Gesundheit, Behaglichkeit und Sicherheit des Wohnens und des Aufenthaltes. In Köln ist der obligatorische Anschluss an die städtische

Wasserleitung für alle Wohngrundstücke eingeführt, welche nicht den Besitz eines Brunnens mit gesundem Grundwasser nachweisen.

Ebenso unentbehrlich ist die Schaffung bequemer und billiger *Verkehrsmittel*, um der gesundheitsschädlichen Wohnungs-Ueberfüllung entgegen zu wirken und auch den entfernten Wohnungen den Broderwerb im Stadtkern oder anderen Stadttheilen zu erleichtern. Diese Frage spielt wohl in allen Grossstädten; fast nirgendwo reichen die örtlichen Verkehrsanlagen aus. Die Stadt Köln plant gegenwärtig ein ganzes Netz von Schmalspurbahnen zur besseren Erschliessung der Umgebung, da die bestehenden Strassenbahnverbindungen mit den Vororten dem Bedürfniss bei weitem nicht entsprechen.

Um der *Wohnungsnoth*, diesem schlimmen Uebel aller moderner Gross- und Mittelstädte, entgegenzutreten, ist es ferner nöthig, die Erweiterung und den Ausbau der Stadt so zu entwerfen und *auszuführen*, dass ein angemessener Vorrath zweckmässiger Baugrundstücke in passender Grösse stets vorhanden sei. Die Blockgrösse kann nicht schematisch festgestellt werden, sondern hat sich nach der zweckmässigen Bauart der zukünftigen Baulichkeiten zu richten: kleine Blöcke für Arbeiterwohnungen, mässige Blöcke für bessere Wohnungen und Geschäftsviertel, grosse Blöcke für Gewerbebetriebe. Für Häuser mit Stockwerkwohnungen (Zinshäuser, appartment-houses, flats) sind Blöcke von bescheidenen Tiefen zu empfehlen, damit nicht das Streben nach thunlichster Ausnutzung des Bodens zur Errichtung grosser Hinter- und Quergebäude führe. Bei Blöcken für offene Bebauung mit Villen, besonders mit Einfamilienhäusern, sind grössere Abmessungen zweckdienlich, um geräumige Gärten zu ermöglichen. In der Kölner Stadterweiterung schwankt hiernach die Blockgrösse zwischen 2,200 und 48,000^{qm} bei 36 bis 130^{m} Tiefe.

Die gesundheitlich gute Anordnung und Einrichtung der Gebäude, Arbeitsstätten und Wohnungen ist die Aufgabe der Bauherren und Baumeister. Die Erfüllung dieser Aufgabe ist unentbehrlich, damit nicht die öffentliche Fürsorge hinsichtlich der Strassen und Plätze, der Pflanzungen und der Kanalisation, der Wasserversorgung und Beleuchtung, der Verkehrseinrichtungen und der Baugrundstücke in ihrem Erfolge vereitelt werten.

C. *a. Amtliche Maassnahmen positiver Art.*—Um die erörterten hygienischen Erfordernisse zu erreichen, sind zahlreiche theils positiv, theils negativ wirkende Maassnahmen seitens des Staates und der Gemeinde zu ergreifen und durchzuführen.

Dahin gehört in erster Linie die Aufstellung eines umfassenden, zweckmässigen Bebauungsplanes für die Stadterweiterung, welcher sich erstreckt auf alle im Anbau bereits begriffenen und zum Anbau in den nächsten zwanzig Jahren voraussichtlich bestimmten Theile der städtischen Umgebung, und damit im Zusammenhange die Aufstellung eines zweckmässigen Bebauungsplanes für die Verbesserung der alten Stadttheile. Wenn wir den Bebauungsplan auf eine 20jährige Entwickelungszeit bemessen wollen, so ist das selbstredend nur annähernd zu verstehen. Ein Plan für eine wesentlich kürzere Frist unterliegt der Gefahr, schon nach wenigen Jahren sich als unzureichend zu erweisen, da der Anbau nicht geschlossen, sondern mit Lücken zu

erfolgen pflegt. Ein für eine wesentlich längere Frist bestimmter Erweiterungsplan läuft Gefahr, einer Entwickelung nachtheilig vorzugreifen, deren Vorbedingungen sich noch nicht erkennen lassen Die räumliche Ausdehnung des Erweiterungsplanes ist ferner abhängig von dem zu erwartenden Bevölkerungszuwachs. Ein Jahreszuwachs. von 2%, 3%, 4% bedingt in 20 Jahren bei gleichbleibender Wohndichtigkeit eine Vergrösserung des bebauten Weichbildes um 48, 80, 119%. Zur Anstrebung verminderter Wohndichtigkeit ist eine noch grössere Ausdehnung des Bebauungsfeldes erforderlich. Der Fortschritt der Entwickelung bedingt ein entsprechendes beständiges Fortschreiten der Planfeststellung.

Die gleichzeitige Planfestsetzung für die Verbesserung der alten Stadttheile aus Gründen des Verkehrs oder der öffentlichen Gesundheit wird in den meisten Städten zu wenig systematisch betrieben. Eine bloss gelegentliche Thätigkeit genügt auf diesem Gebiete nicht, sondern die Beseitigung vorhandener Missstände und die Berücksichtigung der Rückwirkung der Neuanlagen auf die Altstadt bedarf einer andauernden, planmässigen Aufmerksamkeit.

Zum Theil mit der Bearbeitung der Bebauungspläne im Zusammenhange, zum Theil selbständig nebenher sind einheitliche Entwürfe für Entwässerung, Abfuhr, Hochwasserschutz, Wasserversorgung und Beleuchtung aufzustellen und beständig, nicht dem Bedürfnisse folgend, sondern demselben voranschreitend, zu erweitern. Die Entwässerungsfähigkeit des Baugeländes ist eine der wichtigsten hygienischen Forderungen; sehr beträchtliche Strassen-Aufhöhungen, bis 5 ja 7^{m}, sind für diesen Zweck gerechtfertigt. Jedenfalls sollen alle Wohnräume und womöglich auch die Keller dem Einflusse des Hochwassers eines Flusses oder des Grundwassers entzogen werden. Der sichere Anschluss aller Keller an das unterirdische Kanalnetz ist dringend erwünscht.

Die Entwürfe für Verkehrsanlagen und deren Ausführung sollen ebenfalls dem Bedürfnisse nicht nachfolgen, sondern ihm vorauseilen. Strassenbahnen, Stadteisenbahnen und Vorortbahnen erleichtern oder ermöglichen erst eine zerstreutere Bebauung, eine gesunde Ausbreitung der städtischen Bevölkerung. Nur im geringen Umfange haben bisher die Gemeinden selbst die Errichtung und den Betrieb von Verkehrsanlagen in die Hand genommen. Täuschen wir uns nicht, so bereitet sich auf diesem Gebiete ein Umschwung im Sinne des stärkeren Eingreifens der communalen Thätigkeit vor. Aber auch auf Privatunternehmungen können die Gemeinden fördernd einwirken durch geeignete Bedingungen bei Gewährung und Verlängerung lukrativer Concessionen, durch Zinsbürgschaften und ähnliche Mittel.

Es genügt nicht, dass die Gemeinde bloss als Polizei- und Aufsichtsbehörde den Privatunternehmungen zuschaut. Besonders die ausgiebige Anlage neuer Strassen mit allen dazu gehörigen Veranstaltungen ist eine hochwichtige Aufgabe der Gemeinde, sowohl um die Gemeindeländereien der Bebauung zu erschliessen, als um die Privatländereien in Anbaugrundstücke umzuwandeln, letzteres insoweit als die Privatthätigkeit nicht ausreicht, um einen angemessenen Vorrath

an bebauungsfähigen und zur Bebauung bereit gestellten Grundstücken stets zu sichern.

Denn gegen die der Städte-Erweiterung, d. h. der Vermehrung der Wohnungen, so sehr nachtheilige Preistreiberei der Grundstücke giebt es kein wirksameres Mittel als die *Vermehrung des Angebotes*. Die Vermehrung der Wohnungen ist aber Vorbedingung für alle Maassregeln zur Milderung der Wohnungsnoth, zur Beseitigung der Wohnungs-Ueberfüllung, zur Verbesserung oder Schliessung oder Vernichtung gesundheitlich schlechter Wohnungen. Als beispielsweise die Stadt Köln vor einigen Jahren in der Lage war, eine Fülle fertiger Baugrundstücke zu mässigen Preisen an den Markt zu bringen, war eine unwiderstehliche Einwirkung auf die engen, schlechten Wohnungen der Altstadt zu beobachten, welche in grosser Zahl theils verbessert, theils niedergelegt und durch bessere Wohnungen ersetzt wurden, zum Vortheil nicht bloss der Miether, sondern auch sehr vieler Eigenthümer.

Zur Bereitstellung vieler neuer Baugrundstücke genügt aber nicht die Anlage der Strassen und ihres Zubehörs an Pflanzungen, Verkehrseinrichtungen und unterirdischen Werken. Es muss hinzutreten die freiwillige oder zwangsweise vorzunehmende *Umlegung und Zusammenlegung* der nach Lage, Gestalt und Grösse zur Bebauung ungeeigneten Landparzellen in Baugrundstücke, welche den festgestellten und ausgeführten Strassenzügen entsprechen. Aus manchen Gründen ist es bekanntlich nicht möglich und nicht zweckmässig, das städtische Strassennetz nach den zufälligen Begrenzungen der vorhandenen Landparzellen zu richten. Die Strassen schneiden die Grundstücksgrenzen meist unter spitzen Winkeln, manche Grundstücke kommen gar nicht an eine Strasse zu liegen, von andern bleiben nur unförmliche Reste zu beiden Seiten der Strasse übrig. Die Landparzellen sind oft sehr schmal und von grosser Länge, so dass sie weder in der Längenrichtung noch in der Breitenrichtung zur Bebauung sich eignen. Der seitherigen Parzellirung aus landwirthschaftlichen Rücksichten, der seitherigen Zerlegung des Besitzes durch Kauf und Erbtheilung liegen die Rücksichten auf die nunmehrige Bestimmung zur städtischen Bebauung nicht zu Grunde, weil die Linien des städtischen Strassennetzes nicht vorherzusehen waren, auch der Einfluss des Einzelnen sich auf sein Eigenthum beschränkt. Die Umlegung des Besitzes nach Maassgabe der neuen Anbaustrassen erfordert aber naturgemäss die Mitwirkung mehrerer Eigenthümer, gewöhnlich sogar aller Eigenthümer eines von Strassen umgrenzten Blocks. Ein einziger Eigenthümer kann oft die Regelung des ganzen Blocks verhindern, sei es aus Eigensinn, sei es aus berechnetem Eigennutz. Die Kölner Stadterweiterung ist leider reich an solchen Beispielen menschlichen Uebelwollens, und ganze Blockgruppen können heute noch nicht der Bebauung erschlossen werden, weil einzelne Besitzer der Grenzregelung dauernd widerstreiten. Zuweilen gelingt es, alle Betheiligten nach längeren Verhandlungen auf einen Umlegungsplan zu vereinigen: der Vorwärtsstrebende muss dabei dem Zurückhaltenden Opfer bringen. Oft aber ist jede Mühe umsonst; und wenn schliesslich das Verkehrsbedürfniss die Ausführung des

Strassenbaues gebieterisch verlangt, so werden die missgestalteten, schiefen, ineinander geschachtelten, einander schädigenden Grundstücke alsdann ohne vorherige Regelung bebaut, zum grossen wirthschaftlichen Nachtheil der zeitigen Eigenthümer, aber zum noch grösseren, dauernden, wirthschaftlichen und gesundheitlichen Nachtheil der zukünftigen Bewohner-Generationen.

Daraus folgt die Nothwendigkeit des gesetzlichen Eingreifens behufs Umlegung und Zusammenlegung städtischer Baugrundstücke, falls die freiwilligen Bemühungen nicht zum Ziele führen. In einzelnen Staaten, z. B. im Grossherzogthum Hessen, giebt es ein solches Gesetz; in den meisten Ländern bildet das Fehlen desselben eine grosse Erschwerniss des Städtebaues, auch in hygienischer Beziehung.

Der Schwerpunkt der Wohnungsfrage liegt in der Verbesserung der alten und in der Beschaffung zahlreicher neuer Wohnungen für die unbemittelten Volksklassen. *Der Neubau von Wohngebäuden letzterer Art ist daher seitens des Staates und seitens der Gemeinde zu begünstigen.* Selbst Wohnhäuser für Unbemittelte zu errichten, ist nicht die Aufgabe der Gemeinde oder des Staates; von dieser Bethätigung des Sozialismus sind wir hoffentlich noch recht weit entfernt. Das ist Sache der Gewerbetreibenden, der Kapitalisten, der Arbeitgeber, gemeinnütziger Vereine und genossenschaftlicher Unternehmungen. Aber Staat und Gemeinde können diese private Thätigkeit wirksam unterstützen durch die Anlage von Strassen und Bereitstellung von Baugründen in der vorbesprochenen Weise, durch zweckdienliche Eintheilung des Strassenplanes, durch öffentliche Pflanzungen, durch Ermässigung oder Erlass von Immobilarsteuern und Strassenbau-Abgaben, durch billige Lieferung des Wassers u. s. w. Nur an wenigen Orten hat bisher eine derartige fördernde Mitwirkung der öffentlichen Gewalten zur Lösung der Wohnungsfrage, welche vielleicht als die bedeutsamste aller hygienischen Tagesfragen bezeichnet werden darf, in systematischer Weise stattgefunden. Zwar entspricht der Mehrbedarf an Wohnungen nicht immer der Zunahme der Bevölkernng; bei steigendem Wohlstand überwiegt der Wohnungsbedarf, in Zeiten schlechten Geschäftsganges bleibt der Wohnungsbedarf zurück, weil Viele sich einschränken. Aber im Allgemeinen ist der Bedarf besonders an kleinen Wohnungen stets ein grosser, und es ist eine Thatsache, dass die Spekulation aus sich diesen Bedarf an kleinen Wohnungen nicht zu erfüllen pflegt.

Gesundheitspolizeiliche Bauvorschriften für alle zu errichtenden Gebäude sind gegenüber dem Bestreben des Grundbesitzers, die Rente seines Grundstücks durch möglichst dichte und möglichst hohe Bebauung zu steigern, unentbehrlich. Zur Regelung der Beziehungen zwischen den Gebäuden, der Strasse und dem Grundstück bedarf es der Vorschriften über die Abstände der Gebäude von einander und von der Strasse, sowie über die Höhe der Gebäude an den Strassen und an den Höfen und über die Grösse der letzteren.

Was die Gebäudeabstände betrifft, so ist die gesundheitlich beste Anordung des Wohnhauses offenbar die Freistellung ringsum. Zu erreichen ist das nur durch die sogenannte *offene Bauweise*, auch Villenbau oder Cottagesystem benannt. Allgemein ist eine solche

Bauweise aber undurchführbar. Sowohl im Inneren der Städte als auch in äusseren Geschäftsstrassen ist der geschlossene Reihenbau aus wirthschaftlichen und gewerblichen Gründen nothwendig; die offene Bauweise muss daher auf bestimmte Stadttheile beschränkt werden, wo sie aber strenge durchgeführt werden sollte. Sie ist eine hygienische Wohlthat nicht bloss für die Bewohner des einzelnen Hauses, sondern mehr noch wegen der freien Durchfluthung der Strassen und Blöcke von Luft und Licht für das ganze Stadtviertel und dessen Umgebung und alle dort Wohnenden und Verkehrenden.

An manchen Strassen, wo die pflichtmässige offene Bauweise nicht erreichbar ist, führt die gesetzliche Anordnung von *Vorgärten* zwischen der Strasse und den Häusern wenigstens einen Theil der vorerwähnten hygienischen Vorzüge herbei.

Die Höhe der Gebäude in Bezug auf die Strassenbreite habe ich bereits erwähnt. Schwieriger und, da die meisten Wohnräume einer Stadt nicht an den Strassen, sondern an den Höfen zu liegen pflegen, noch wichtiger ist die Beschränkung der Gebäudehöhe an den Höfen. Der "Entwurf reichsgesetzlicher Vorschriften zum Schutze des gesunden Wohnens," aufgestellt im Jahre 1889 vom Deutschen Verein für öffentliche Gesundheitspflege, lässt an den Höfen eine Gebäudehöhe zu, welche das Anderthalbfache des mittleren Abstandes von der gegenüberliegenden Begrenzung des unbebauten Raumes beträgt. Einen hygienischen Grund, an den Höfen ein ungünstigeres Verhältniss zwischen Höhe und unbebauter Breite zuzulassen, als an der Strasse, giebt es nicht. Der Entwurf des deutschen Vereins trägt also schon, dem Zwang der Umstände folgend, der herrschenden engen Bauweise, welche nicht mit einem Schlage beseitigt werden kann, gebührend Rechnung. Der auf dem internationalen Kongress in Wien von Trélat gemachte Vorschlag, die oberen Stockwerke der hohen Gebäude zu enteignen und niederzulegen, würde zwar das Uebel beseitigen; aber kein Staat und keine Gemeinde vermag die Geldmittel aufzubringen, welche zur Ausführung einer solchen Enteignung erforderlich sein würden. Die in vielen Bauordnungen enthaltenen Bestimmungen, dass ein aliquoter Theil des Grundstücks, etwa $\frac{1}{3}$ oder $\frac{1}{4}$, unbebaut bleiben müsse, fällt nicht mit dem hygienischen Interesse zusammen, da für letzteres das günstige Verhältniss der Hofräume zur Gebäudehöhe, nicht das Verhältniss der Hofräume zur Grundstücksgrösse maassgebend ist. Die von einigen Schriftstellern empfohlene Festsetzung rückwärtiger Baufluchtlinien, welche die Gebäudetiefen beschränken, also das Innere des Blocks von der Bebauung frei halten sollen, halte ich nur in Ausnahmefällen für durchführbar.

Bezüglich der inneren Gebäude-Einrichtungen sind Vorschriften erforderlich über die geringste Höhe der Wohnräume (2·5 oder 3^{m}), bez die geringste Lichtfläche der Fenster ($\frac{1}{10}$ oder $\frac{1}{12}$ der Zimmerfläche), grösste Zahl der über einander liegenden Wohngeschosse (4 oder 5) über hochwasserfreie und grundwasserfreie Lage der Wohnräume, über den Schutz gegen aufsteigende Feuchtigkeit, über die Beschaffenheit von Wohnräumen im Kellergeschoss, über Zahl und Beschaffenheit der Aborte, der Entwässerungs- und Leuchtgas-Leitungen. Ich muss mich hier damit begnügen, auf den oben erwähnten "Entwurf

reichsgesetzlicher Vorschriften," sowie auf die Schriften über Hausentwässerung von W. P. Gerhard in New-York hinzuweisen.

b. Amtliche Maassnahmen negativer Art.—Gesetzliche oder polizeiliche Verbote auf dem Gebiete der Wohnungsfrage sind erst dann zulässig und können auch erst dann wirksam sein, wenn durch die vorbeschriebenen positiven Maassnahmen die Entstehung gesunder und zweckmässiger Wohnungen in ausreichender Zahl herbeigeführt oder gesichert ist.

Die ersten beiden Verbote betreffen alsdann die Herstellung von Bauten, welche gegen den veröffentlichten Stadtbauplan verstossen, sowie solcher Bauten, welche an unfertige Strassen errichtet werden sollen, d. h. an Strassen, in welchen für den Fahr- und Gehverkehr, für Wasserzuführung und Wasserabführung und für die Beleuchtung noch nicht ausreichend oder noch gar nicht gesorgt ist. Das erstere Verbot besteht in allen Kulturstaaten mit wenigen Ausnahmen, das zweite Verbot dagegen ist noch keineswegs allgemein verbreitet. In Preussen ist den Gemeinden das Recht verliehen, das Bauen an unfertige Strassen durch Ortsstatut zu verbieten. Aber über eine bloss finanzbüreaukratische Handhabung dieses Verbotes, dem doch die systematische Fertigstellung einer ausreichenden Zahl von Strassen für den Anbau gegenüberstehen müsste, haben sich leider im Allgemeinen die preussischen Städte nicht erhoben. Das Verbot wird nämlich in der Regel nur ausgesprochen, wenn der Baulustige den für seinen Fall von der Gemeinde geforderten Beitrag zu den Herstellungskosten der Strasse zu zahlen ablehnt. Im Uebrigen pflegt man das Bauen auch an unfertigen Strassen fast regelmässig zu gestatten, für die Fertigstellung der Strassen aber nicht dem Baubedürfnisse wie es sein müsste vorauf-gehend, sondern nur dem Baubedürfnisse sehr langsam folgend, Sorge zu tragen. Diese den Bau von Wohnungen mehr erschwerende als fördernde Gemeindepolitik ist hygienisch durchaus nicht zu billigen.

Ein drittes Verbot bezweckt, die Freihaltung gewisser Stadtviertel, namentlich solcher, welche für offene Bauweise bestimmt, welche wegen gärtnerischer Anlagen oder sonstiger öffentlicher Pflanzungen besonders für ruhiges Wohnen aufgesucht werden, welche Kranken- oder Genesungsanstalten enthalten, von lästigen Gewerbebetrieben. Ausdünstungen, Rauch und Lärm können die Gesundheit und Annehmlichkeit des Wohnens erfahrungsgemäss ernstlich gefährden und manche hygienischen Maassregeln unwirksam machen. Ein örtlich beschränkendes Verbot derartiger gewerblicher Anstalten ist desshalb gerechtfertigt, namentlich, wenn für gute gewerbliche Vorbedingungen in anderen Stadttheilen seitens der Behörden gesorgt wird.

Das Verbot des Bewohnens gesundheitsschädlicher Räume, sowie das Verbot der Wohnungs-Ueberfüllung und die Niederlegung derjenigen gesundheitsschädlichen Gebäude und Gebäudegruppen, welche nur durch völligen Neubau zu saniren sind, dies sind hygienische Nothwendigkeiten, da die schlechten und überfüllten Wohnungen nicht allein für die Bewohner unmittelbar, sondern durch Ansteckung und Entsittlichung auch für die Allgemeinheit verderblich werden. Der Neubau gesunder Wohnungen und *die Verbesserung schlechter*, aber noch gebrauchsfähiger Wohngebäude muss natürlich mit diesen Verboten

Hand in Hand gehen. Ob die schädliche Ueberfüllung schon vorhanden ist, wenn eine Familie weniger als 20^{cbm} Wohnraum pro Kopf besitzt, oder ob das Vorhandensein eines Schlafraumes von 10^{cbm} pro Kopf genügt, das lässt sich schwerlich auf blossem wissenschaftlichen Wege feststellen. Man wird mit dem wirthschaftlich Erreichbaren sich begnügen und eine *allmälige* Gesundung der durch örtliche Enquêten festzustellenden Wohnungsverhältnisse anstreben müssen.

D. *Gesetzgebung.* — Die geschilderten positiven und negativen Maassregeln der Gemeinde und des Staats sind nur ausführbar auf Grund einer entsprechenden Gesetzgebung. Sechs Gesetze sind es hauptsächlich, welche sich nach den bisherigen Erfahrungen und nach den Berathungen der hygienischen Vereine als nothwendig erwiesen haben.

Zunächst ein Gesetz über die Feststellung von Baufluchtlinien und Bebauungsplänen. Das preussische und mehr noch das hessische Gesetz über diesen Gegenstand entsprechen ziemlich, wenn auch nicht vollkommen, den gesundheitlichen Anforderungen. In manchen Staaten ist dieser Zweig der Gesetzgebung noch wenig ausgebildet, in anderen herrscht noch Unklarheit und Willkür.

Das Enteignungsgesetz ist gleichfalls in den meisten Staaten noch unvollkommen. So kann man z. B. in Preussen zwar das zukünftige Strassenland enteignen, nicht aber die bebauungsunfähigen Restgrundstücke neben der Strasse (welche in der Hand eigennütziger Besitzer den Anbau behindern oder verschlechtern) und ebensowenig solche Gebäude und Gebäudegruppen, deren Beseitigung im Interesse der öffentlichen Gesundheit gefördert werden muss. Frankreich und England sind auf diesem Gebiete erfreulich vorgeschritten, wenngleich sowohl die bezügliche französische Gesetzgebung als die englischen Torrens- und Cross-Acts der weiteren Entwickelung und namentlich der wirksameren Handhabung bedürfen.

Ebenso nothwendig ist ein Gesetz über die oben besprochene, banfähige Umlegung und Zusammenlegung unbebauter städtischer Grundstücke, sowie ein Gesetz, welches die Ausschliessung lästiger Fabrikanlagen aus reinen Wohnvierteln ermöglicht.

Von entscheidender Wichtigkeit aber sind hygienisch durchdachte Gesetze über das Bauen und über das Wohnen. Baugesetze besitzen wohl alle Kulturstaaten ; aber nöthig ist deren Durchsicht vom Standpunkte der öffentlichen Gesundheitspflege und die allgemeine Festsetzung der als Mindestforderung zu beobachtenden hygienischen Vorschriften, deren Durchbildung und Verschärfung nach örtlichem Bedürfniss und wirthschaftlicher Erreichbarkeit die Pflicht der einzelnen Gemeinden ist.

Eine hygienische *Wohnungs-Gesetzgebung* steht gegenwärtig in Deutschland, in Oesterreich, in England, in Frankreich, in Italien auf der Tagesordnung. Die Frage wird nicht verschwinden, bis sie gelöst ist. Sie ist ein wichtiger Zweig der allgemeinen sozialen Frage. Allgemeine gesetzliche Vorschriften über die Vermiethung und die Benutzung der Wohnungen, gegen die Ueberfüllung und Verwahrlosung derselben, sind überall als ein Bedürfniss der Gegenwart erkannt.

Es würde zu weit führen, hier des Näheren auf diesen wichtigen Gegenstand einzugehen. Der Zweck dieses Vortrags ist erfüllt, wenn es mir gelungen ist, die *allgemeine Aufgabe*, welche uns bei der Erweiterung und dem inneren Ausbau der Städte gestellt ist, die *hygienischen Erfordernisse*, welche Vorbedingung sind für das gesunde Wohnen und den gesunden Aufenthalt in unseren Städten, sowie die *amtlichen Maassnahmen* positiver und negativer Art, welche zur Befriedigung jener Erfordnernisse geeignet sind, annähernd darzulegen und schliesslich die Hauptpunkte anzugeben, über welche die *hygienische Gesetzgebung* im städtischen Bau- und Wohnungswesen sich zu erstrecken hat. Every man may do his duty!

DISCUSSION.

Mr. John Slater said that so large a subject could not be disposed of in fifteen minutes. There was matter sufficient for the whole sitting, and even for an adjourned discussion. The great difficulty in London was its enormous size. The distances in continental cities were as nothing to those in London. Nearly all the continental cities, too, had been fortified, and the disused fortifications could be best utilised now by turning them into boulevards and open spaces. Herr Stübben had rendered good service by advocating a regulation to restrict the height of buildings in narrow thoroughfares. Even we in London moved far too slowly in this respect. Herr Stübben was entitled to our warmest thanks for coming here to tell us what was being done abroad for the extension and internal improvement of towns.

Mr. Rogers Field said that byelaws for the regulation of buildings and drainage had been of the greatest utility, but he very much questioned whether the regulations relating to houses were scientific. In the little town of Uppingham he had seen a good deal of the working of such regulations from the beginning, and he found quite as much indirect advantage from them in the education of the public mind on sanitary questions as of direct advantage. It was often urged that byelaws might be serviceable for new buildings, but how about the old ones? The answer suggested by his experience was, that if once the principle were adopted by the people generally, it would be applied by them to old buildings as well as to new. If people saw it was to their advantage they would make the regulations apply to both.

Mr. Thomas Blashill, Superintending Architect to the London County Council, regretted the tendency to consider the question as too large a one to be effectively dealt with. It was considered by many people not possible to make an old town perfectly habitable. The question had been taken up by faddists and inexperienced persons, which accounted for their failure to find the solution. If approached in a scientific spirit, and backed by sufficient funds, there was no reason to despair of a practical solution of the problem being found.

Herr Ludwig Techner (Budapest) sagte,—die Gesetze und Regeln die uns Herr Stübben empfiehlt und die er selbst in Köln so glänzend zur Geltung gebracht hat, sind wohl die richtigen, doch lassen sich diese nicht so leicht überall gleichmässig anwenden, und zwar sind wohl Klima, Gewohnheiten und bestehende Verhältnisse von grossem Einfluss auf die Möglichkeit der Durchführung. So können diese in Stadttheilen,

welche oft auch historische Bedeutung haben, schwer durchgeführt werden, und sind hierzu meistens gewisse Vorwaltensregeln erforderlich, die sehr häufig den Widerstand der Bevölkerung herausfordern und mit ungewöhnlichen finanziellen Opfern verbunden sind. Die schädliche Ueberspeculation mit Bau-Gründen und Hinauftreibung der Reichen kann wohl durch grösseres Angebot ermässigt werden, doch ist dies mit dem Nachtheil verbunden, das Strassen und Strassen-Einrichtungen für grosse Complexe im Voraus hergestellt, auch erhalten werden müssen, bevor die Verbannung erfolgt, und dies vertheuert die empfohlene Methode. Wo möglich sind solche Umänderungen und Erweiterungen populär zu machen, und Eingriffe privatrechtlicher Natur nicht zu forciren, wo diese nicht unbedingt nothwendig sind. Bei Anlagen von Baumpflanzungen ist wohl auch das Klima massgebend, Rasenflächen im südlichen Klima nur mit grossen Kosten schön zu erhalten. Wo also Verhältnisse und Umstände es erlauben, sind die empfohlenen Regeln anzuempfehlen und werden gewiss zu sehr günstigen Resultaten führen.

Hygiène des Groupes d'Habitations à Bon Marché.

PAR

M. Charles Lucas, Architecte à Paris, &c.

Les efforts tentés actuellement pour réunir, aux abords d'une grande exploitation ou dans certains quartiers d'une ville industrielle, des habitations de divers genres, telles que des maisons à étages comprenant quelquefois des chambres garnies ou non mais toujours plusieurs logements par étages, et des petites maisons, isolées ou groupées, mais affectées chacune à une ou deux familles au plus, entraînent, outre l'étude générale des données de l'hygiène propres à chacun de ces modes d'habitation, une étude particulière des données de l'hygiène spéciales à l'ensemble de ces habitations et à leur groupement.

Cette hygiène, à la fois publique et privée, morale même, qui, de plus, ne doit pas être étrangère à toute préoccupation d'assurer un certain charme pittoresque à l'ensemble des habitations à créer non plus qu'à toute économie réalisable par suite du groupement de ces habitations, se rapporte à la fois aux deux grandes divisions :—I. *Création et agrandissement des Villes ; et II. Construction*, en même temps qu'à divers alinéas du programme de la Section VI. ; car, pour ces groupes d'habitations à bon marché, il y aura à se préoccuper, à une échelle restreinte, il est vrai, des espaces libres à réserver (A) et des rues intérieures (B) ; toutes les conditions d'une bonne construction devront y être soigneusement recherchées ; de plus, ces groupes participeront à la fois des habitations particulières (C) et des habitations communes (D) ; enfin, si, comme il est désirable de le voir réaliser, des locaux industriels (E) et quelques bâtiments publics (F), locaux et bâtiments réservés à l'usage seul des habitans des groupes ainsi créés, viennent

faire de ces ensembles d'habitations à bon marché comme un quartier dans une ville, aucune des préoccupations qui ont si judicieusement inspiré les auteurs du programme de la section VI. (Architecture appliquée à l'hygiène) ne devra rester étrangère à cette étude.

C'est donc une vue d'ensemble des nombreux points que soulève l'hygiène du groupement des divers genres d'habitations à bon marché que l'auteur se propose d'exposer, vue d'ensemble dont il s'efforcera de préciser les données multiples par des exemples pris sur des types existants.

DISCUSSION.

Mr. Wm. White said the question of rent must always depend on the value of land, and whatever could be done to get land at a lower price should be within the question.

Mr. H. H. Statham referred to a point not hitherto touched upon, the spacing between blocks of dwellings. The building of high blocks in order to make the most of the value of the ground, unless the buildings were spaced proportionally farther apart, was just as much overcrowding as cramming people together in lower buildings in narrow streets. Moreover, the high buildings, unless far enough apart, shut out the sunlight from each other. Light was most important, and in some collections of blocks in London this consideration has been flagrantly neglected.

The Control of the Construction of Dwelling-houses.

BY

THOMAS BLASHILL, F.R.I.B.A., Superintending Architect to the London County Council.

The right and the duty of the public authority to make and to enforce regulations for the construction of habitable buildings, with proper regard to their healthy occupation, have been recognised in this country by many special Acts of Parliament affecting the metropolis and our larger towns, and also by the Public Health Act, which is applicable wherever the density of a population renders such regulations necessary. The laws of other countries generally recognise the same right and duty.

The chief structural conditions of a habitable building which are recognised as being necessary for its healthy occupation are these :—

1. It must stand upon a site the subsoil of which is naturally dry, or is properly drained and free from impurity; and effective means must be taken to prevent the admission of air from the soil into the building.

2. The building materials—particularly the bricks, the mortar, and the plaster of the walls—must be of good quality, so that neither moisture nor impure air can be admitted through them into the building, and means must be taken to prevent the moisture from the ground rising up the walls.
3. All parts of the building, and not merely those parts which are actually inhabited, must be properly ventilated and lighted, the habitable rooms being of sufficient size and particularly of sufficient height.
4. Provision must be made for the removal of refuse, whether solid or liquid, from the building, and from its near neighbourhood, before this refuse begins to pollute the air.

In order to show how these matters may be dealt with by law, I will, in the first place, give the regulations which are now in force in London and applicable to each of these necessary structural conditions.

The Metropolitan Buildings Act and the Metropolis Local Management Act were passed in 1855, and have been since amended by several Acts, some of which give to the London County Council a limited power of making byelaws. So far as these Acts and byelaws relate to buildings, they are chiefly intended to provide for the sound construction of walls and the prevention of fires. The regulations that relate to health as affected by construction are few and not very efficient for their purpose.

As regards the sites of buildings, the byelaws made under the Amendment Act of 1878 require that they shall be cleared of any material impregnated or mixed with fæcal, animal, or vegetable matter, dust, or slop, or other refuse with which they have been filled up or covered, and the holes thus formed must be filled up with "hard brick or dry rubbish." The Amendment Act of 1890 empowers the council to make byelaws regulating the mode in which any excavation made within 3 feet of a building shall be filled up. The object is to clear the site from impurity, but when I say that the existing byelaws were found insufficient to prevent the erection of houses upon a disused cemetery filled up by interments, some idea may be formed of the difficulties that beset the makers of regulations for sanitary purposes. Under the Public Health Act, 1875, certain byelaws have been framed by the Local Government Board applicable to the cases of urban and rural sanitary authorities, and these are now generally adopted outside the metropolis, with or without modifications sanctioned by that Board. The new byelaws of the city of Manchester, approved in 1890, probably give their best and most modern form. They require, in addition to the removal of any impure material from the site, the removal of any such matter as may have been deposited upon the site, but they are silent as to the filling up of any holes left by the excavation.

The Metropolitan Regulations make no provision for the drainage of a site that is naturally damp. The Model Byelaws provide that the subsoil shall be drained with earthenware field pipes, which shall be trapped and ventilated at their junction with the foul drain of the house. In a district where much of the subsoil had been excavated for the

removal of clay and gravel a byelaw was approved prohibiting the erection of a building until a layer of sound and suitable material sufficient to elevate the site to an adequate height had been deposited thereon. It seems generally desirable to treat a site that is naturally damp or soaked in moisture in this way, for an ordinary field drain is not permanently efficient, and there is no security that the trap will always prevent the passage of foul air into a porous subsoil.

The Metropolitan Byelaws require that, unless a site is gravel, sand, or natural virgin soil, it shall be covered with a layer of good concrete 6 inches thick, and smoothed on the upper surface. This concrete, which is usually made with lime, is of very little practical utility, and the exception of certain kinds of site is very unfortunate. The Model Byelaws admit of no exceptions, and require the site to be covered with asphalte or with a 6-inch layer of good cement concrete rammed solid. The object being to prevent the admission of ground air into the house, this cement concrete should be either asphalted or grouted on the surface with cement properly smoothed, as even the best concrete will allow the passage of moisture and of air. The Metropolitan Byelaws are silent as to ventilation under the wooden floors of the lowest story, but the Manchester Byelaws provide for a ventilated space beneath the floor timbers. I have, however, long been convinced that there ought to be no wooden floors of the ordinary construction in the lowest story of a house, and no space, ventilated or unventilated. The air-inlets are invariably stopped up to prevent cold and draughts, and, at the best, the space must be a means of introducing stagnant or ground air into the house. If brick or stone paving would be too cold, floor-boards 1½ inch thick, Burnettized or Ryanized, may be nailed to narrow fillets embedded in the concrete about 3 feet apart, or they may be nailed to a layer of coke breeze and cement, concrete, or the ordinary wood flooring blocks may be used. Thus the cost of excavation and of floor timbers may be saved, and a solid impervious floor obtained.

Burnt bricks and bad mortar permit the passage of moisture through walls. Mortar and plaster mixed with putrid or earthy matter increase this mischief and pollute the air. The Metropolitan Buildings Acts and Byelaws demand good, hard, sound, well-burnt bricks, and mortar composed of fresh burnt lime or cement and clean sharp sand or grit "without earthy matter." This last item is very important, for earthy matter can be easily detected by the eye and separated by analysis. The London Council General Powers Act, 1890, gives power to the Council to regulate the composition of plaster, which hitherto could be made chiefly of foul road scrapings or garden mould. The materials demanded will be generally similar to those required for mortar.

The provision of a damp course near the base of a wall is most important. The Metropolitan Byelaws demand that it shall be of "asphalte or other material impervious to moisture" placed one foot above the level of the ground in external walls, and six inches below the lowest floor in internal and party walls. Thus in external walls there is no provision against the passage of damp at the level of the ground or below that level. The Manchester Byelaws require a damp course of sheet lead of four pounds to the inch, asphalte half an inch thick, or

slates laid in cement, or of other material impervious to moisture beneath the lowest timbers and at the level of the surface of the ground. If the lowest floor is to be below the surface of the ground the external wall must be double, having a cavity of two inches between the outer and inner portions and extending from the base of the wall to the surface of the ground, with one damp course at the base of the wall and another at the top of the cavity. The Model Byelaws suggest that the cavity should extend to six inches above the surface of the ground, and even that is hardly enough to provide against the splashing of rain. The least that should be demanded is an outer covering or rendering of the wall with asphalte or some effectual material carried down from the damp course which is above the ground to a damp course that is below the floor. But it would not be very unreasonable to demand that the whole of the lowest part of the wall, up to a height of twelve inches above the ground, should be built of hard bricks bedded in cement mortar, as is very usual in good work. There does not appear to be any legal authority at present for demanding a dry area, or even an external coating for the protection of the lower part of a wall, these matters not forming part of the wall.

The supply of light and fresh air to habitable rooms, and the provision of sufficient air-space may be secured by requiring that the rooms be made of adequate size, and particularly of sufficient height—and that they have suitable windows overlooking open spaces. The Metropolitan Buildings Act, 1855, provides that unless all the rooms in a dwelling-house can be lighted and ventilated from a street or alley adjoining, it shall have in the rear or on the side an open space exclusively belonging to it, measuring 100 square or superficial feet. But it has been legally decided that the light and ventilation need not come directly from the outside, and if they are admitted through another room no open space need be provided. If the open space is provided there is no power to secure that any room shall be lighted or ventilated from it. The Amendment Act of 1882 requires that every new dwelling-house erected upon a site not previously occupied in whole or in part by a building shall have directly attached thereto, and in the rear thereof, and extending throughout its entire width, an open space of not less than 150 square feet. If the frontage exceeds 15 feet in length, the space must measure 200 square feet, a frontage over 20 feet must have an open space of 300 square feet, and a frontage over 30 feet must have a space of 450 square feet. But it is permitted to cover the whole of this space with buildings not higher than the ceiling of the ground floor storey of the main structure. In many cases this is very inadequate. The Model Byelaws fix the size of the open space at a minimum of 150 square feet but increase the area in proportion to the height and length of the house. In any case the distance from the rear of the house across the open space must be not less than 10 feet, but if the house is 15 feet in height the distance must be 15 feet—if the height is 25 feet the distance must be 20 feet—and for 35 feet or more of height the distance must be 25 feet, and these widths must be carried all along the rear of the building. These byelaws also enforce open spaces in front of dwelling-houses, and a similar result is obtained by the Metropolitan Regulations

which fix the widths of streets and the heights of buildings. These Model Byelaws also demand that every room shall have a window measuring one tenth of the area of the floor, and one half of it must open so that the opening extends to the top. This window must overlook an open space. And if a room has no fireplace it must have a ventilating opening or shaft of 100 square inches in area. The Berlin Regulations of 1887 provide that lobbies, vestibules, and corridors that have no windows must have tubes or pipes for ventilation. It is difficult to fix by law the size of a habitable room. The Metropolitan Building Act requires that every habitable room shall be 7 feet high in every part, except rooms in the topmost story, which must be 7 feet high over one-half of their area. If in a basement, they must have (in accordance with the Metropolis Local Management Act) 1 foot of their height above the adjoining footway with an open area 3 feet wide along the front.

But the building regulations adopted by the London County Council for artisans' dwellings that are built upon the land which it has to devote to that purpose, indicate the views of that body as to the proper sizes of dwelling-rooms for the lowest class of the population that inhabits separate tenements. The assumption is that the average population will be two persons per room, and the standard height of rooms is to be 9 feet. A one-roomed dwelling is not to be of a less area than 144 square feet; in a two-roomed dwelling the additional room is to measure at least 96 feet square; and in a three-roomed dwelling the third room is also to be of this size. Basement rooms are not to be sunk more than 3 feet below the adjoining pavement, and watercloseets are not to be immediately accessible from dwelling-rooms. These closets are, in those dwellings, generally so arranged with regard to the scullery that a current of air will pass to the other rooms through the scullery and not through the closet. The Model Byelaws provide that the closet shall adjoin an external wall, and shall have a window measuring 2 feet by 1 foot, also a ventilating air-brick or air-shaft; but no regulations can secure these contrivances from being stopped up by the occupiers. It is, I think, a source of evil to assume that a watercloset must be a foul place, and to trust to remedial precautions which, in practice, will never be taken. A closet should, by its construction, be rendered so free from impure air that nothing beyond a window should be necessary to keep it sweet.

The last item I have to notice is the structural measures necessary for the removal of refuse from the house. The modern practice being to take all the liquid refuse of town houses into a public sewer, no question of cesspool construction can arise where sewers exist, and a cesspool cannot in any case be constructed in or near to a house. Questions of house drainage will be dealt with in another department of this Congress, and we have only to notice the structural means of getting liquid refuse into the drain. There are in the metropolis no very precise regulations for that purpose, but byelaws are now under consideration. The Model Byelaws require that the soil-pipe from a closet or slop sink shall be fixed outside a house, and shall be thoroughly ventilated. The waste-pipe from a bath, lavatory, or ordinary sink

must discharge outside the building over a channel leading to a trapped gully 18 inches distant. But there is no provision for a trap under the sink, which is necessary, and there is no satisfactory provision for the trap which forms part of the closet apparatus.

An earth-closet must be lighted and ventilated, as in the case of a watercloset, but I think no earth-closet should be permitted within a building, though with proper arrangements it may be placed close to a building. Privies and ash-pits, where they are permitted, must be placed 6 feet from a building, and 100 feet from any source of water supply. The Model Byelaws give detailed regulations as to these matters. Ashpits (or dustbins) for "dust, ashes, rubbish, and dry refuse," must be built of brickwork, and may contain 6 cubic feet, or such less amount as may be equal to the accumulation of one week. This is a great source of evil, for the kitchen refuse has to be mixed with it. In the city, which forms rather over a square mile of the metropolis, this refuse is collected daily, and no accumulation beyond one or two days ought to be permitted. I think that kitchen refuse should not be mixed with the ordinary dry refuse, such as dust, ashes, and hard-core; the mixture spoils both articles, producing a putrid mass that is unmanageable, and of little value.

I have now given the details of those structural regulations which in this country have been generally considered necessary for ensuring the healthy condition of a house, together with a few observations thereon. Had time permitted I should have been glad to compare our regulations with those in force in the chief continental countries, some of which are very elaborate, but I hope that these will be adequately brought out during this Congress.

The structural conditions of a healthy house do not appear to be numerous, but they are exceedingly difficult to define so that they can be clearly understood and enforced by law. It ought not to be possible to build a house in which the conditions necessary to healthy occupation are violated. Indeed, this can be prevented where the Model Byelaws are in operation, which forbid the occupation of a house until it has been certified to be fit for human occupation. But if this care is necessary in a new house, its necessity can hardly be disputed in the case of old houses, where the conditions are notoriously unsatisfactory. It has been proposed to bring these houses gradually under inspection by fixing a period after which the public authority will be authorised to inspect and order the amendment of defects. This is a matter which, both as to regulations and as to inspection, will demand the greatest care and caution. If it is established, it should apply to all houses without distinction of size or of the class of their occupiers, so that the whole population, the interest of which, as regards health, is common and cannot be divided, should be protected by public law from evils over which individuals can have but little control. And amongst the many sources of sickness and premature death, we should be freed from those which spring from the faulty construction of the house.

DISCUSSION.

Professor Aitchison, A.R.A., said, with regard to the sanitarily-constructed dwelling-houses, they were probably used by mechanics or persons who might be looked upon as the aristocracy of labour. But probably half the population of London did not earn more than about 10*s.* a week, and all these regulations, providing for sand, well-burnt bricks, mortar, best burnt lime, asphalte, and all sorts of things, were absolutely impossible, as these people could not pay the rent for such dwellings. But something must be done to render the habitation of the poor possible. He did not see what could be done unless the wages were to be raised, but that was a question of population, and at present people were willing to work at the lowest wage to avoid starvation. For the houses of the largest class of persons in large towns there was much difficulty in meeting most of these requirements, for the speculative builder knew perfectly well that his houses were useless unless they could be let at a certain price. The consequence was that every kind of bad material and bad workmanship was put into requisition; and every attempt was made to outwit those who were appointed to see to the carrying out of the regulations.

Mr. Coard S. Pain (Liverpool,) said they were all fully acquainted with the fact that it was a greater difficulty to enforce byelaws, however excellent in themselves they might be, than to make them. All of them who had had anything to do with the superintendence of buildings must know how utterly impossible it was to get the byelaws carried out if the builder was short of money or otherwise unable to do his duty. He thought that the official of the local authority should be jointly appointed by the Local Government Board and the rural or urban sanitary authority. They all knew that the general public was utterly indifferent to what was going on. The local authorities were, to a large extent, composed of people directly interested in not carrying out the regulations. One might be as smart as possible, but he would back the jerry builder against the smartest. Unless one actually sat upon the job, it was impossible to compete with him; he would cheat them under their very noses, and the local authorities backed him up for many reasons. One member might be the owner of a great property; another element in the local authority was usually the speculating builder; and it was most difficult for the official, however honest he might be, to fight against these influences. That difficulty should be removed, and he thought the adoption of the suggestion he had made would remove it, the more so as another difficulty in getting the byelaws carried out was the frequent inefficiency or ignorance of the official. He was referring to small communities of from 2,000 to 6,000 inhabitants, just large enough to demand the services of a sanitary official. A carpenter, possessed of no particular knowledge, was appointed as surveyor, and he had come across a surveyor recently who was not even acquainted with the byelaws. The law could not make a man honest, but it could insure the appointment of a competent man.

Dr. G. B. Longstaff, Member of the London County Council, felt some hesitation in rising in the presence of so many experts of whom he expected to seek information rather than to afford them any. It was important that architects should give information to individuals like himself as to what were really the essential points in building legislation to aim at. He would recommend them to throw aside all minor matters,

but to fight for those of great importance. Thus he would like to have the general opinion of architects upon Mr. Blashill's proposal to construct the ground floor with concrete and wood, a suggestion which he thought was quite a new one. If wood was used at all, it should be placed on concrete direct. The advantages were clear enough, but he wanted to know whether such a floor was practicable and durable, and whether a nuisance would not arise from the decay of the wood? It would be impossible to compel the people in London to live on concrete or stone or any similar material. They should have an impervious floor, but covered with wood or other non-conducting material. The greatest difficulty was the great respect which Englishmen always showed, and rightly showed, for vested interests, but the question arose whether the consideration of these vested interests had not gone too far. The Act of Parliament of 1855 gave many powers to the governing body of London to carry out provisions in all buildings which were not erected previously, but a long time had elapsed since then. People had learnt something, and the question was whether it was not time to strike out the existing clauses exempting all houses erected prior to 1855. They should also insist upon suitable open spaces, whether the sites had been occupied previously to 1855 or not. In should not be allowable to pull down an ancient street and build a new one of the same width, or to build a new house on the site of an old one covering the same or a larger area up to an indefinite height. Guides on these points would be of very great value. It was common knowledge, he supposed, that the Government had promised to bring in a Bill for the Consolidation of the Metropolitan Buildings Acts, and that a Committee of the County Council would probably be employed for many months to come in considering the details to be proposed to the Government.

Mr. Edward Bond, Chairman of the East-End Dwellings Company, said that in the model byelaws as sketched out by Mr. Blashill, he found little to object to, and nearly all the regulations he had suggested were such as an honest person doing his duty might very well submit to carry out. But there was the difficulty that a great number of people who went in for building speculation did not very much care what sort of houses they put up as long as they could erect them at the least possible cost. It was a matter of extreme difficulty to secure that byelaws, however excellent in themselves, should be positively enforced and carried out by those whose duty it was to see them carried out. At the present moment, however, they did not discuss the difficulties to be overcome, but what the ideas were as to framing our byelaws. There was nothing unreasonable in the suggestion implied by Mr. Pain in the opening of this discussion, but he could not agree with all that had been said about houses erected previous to 1855, and some of the suggested difficulties did not exist. He should be sorry to think, with Professor Aitchison, that only 10*s.* a week was earned by the average London working man. He would like to know where he had obtained that figure, seeing that, from his own observation, it must be very far from the exact truth. He did not think that the conclusion arrived at by Mr. Charles Booth in his book on London life was very wrong, according to which there was a large number of people earning from 15*s.* to 18*s.* a week. It was very difficult to settle the question how such people, who could only afford to pay 2*s.* 6*d.* to 3*s.* a week for rent, rates, and taxes, could best be lodged. The company with whom he was connected had made some attempts in that direction, and had found they had rooms for people of that class which would be found to satisfy Mr. Blashill's suggested byelaws, varying from

3*s.* 6*d.* to 2*s.* 6*d.* and 2*s.* a week. They had been able to pay their shareholders a dividend of 4 per cent., which was now likely to reach as much as 5 per cent. They did not confine themselves to buildings of that class, but catered also for people who could afford to pay considerably higher rents. He ought to mention that most of the sites upon which their houses were built, and which had been cleared by the Metropolitan Board of Works or by the County Council under the Artisans' Dwellings Act, they had acquired at a rate very much below the strict market value. When he spoke, therefore, of having to a certain extent solved the problem, it should be taken into account that they had paid less for their land than it would have cost in the open market. Otherwise he doubted whether they would have been able to provide rooms which the people could have inhabited, and also to pay a good remuneration to those who had entrusted them with their money.

The Rev. Harry Jones said he was in favour of pulling down any bad house, whatever inconvenience it might cost to anyone. A bad man would sometimes make a bad house, but a bad house would inevitably make a bad man.

Mr. H. H. Statham said he could not agree with the conclusions of his friend, Professor Aitchison, which he thought were entirely false humanity, and illogical. If byelaws were to be relaxed because properly-built houses were beyond the means of the poorer class, in two or three generations we might reach the point where they could only afford straw huts, and the authorities would be called on to permit those in the bye-laws. The enforcement of good building tended to keep up a healthful standard of life, and was a benefit to the community.

Mr. Edwin T. Hall wished to urge the necessity of excluding ground-air and sewer-gas. There was a lamentable want of power to do this in the Building Acts governing the metropolis. There was no regulation whatever having for its object the exclusion of ground-air as such. "Sewer-gas" was guarded against, but it must be remembered that ground-air was almost as deleterious. They would remember that experiments had been made showing that air went through walls of houses at the rate of 16 cubic feet per hour at 30 deg. difference of temperature, and at a difference of 5 deg. the rate was 17 cubic feet. When they remembered that ground-air was charged with carbonic acid gas and gases from organic matters, they would see how deadly this was to the persons inhabiting such rooms. The floor should be protected by asphalte, of which he had been an advocate for many years. There should be no space under the floor, that being a reservoir for stagnant air. They could get no syphon action to ventilate it, the ground being in most cases level on each side. In upstair rooms it was also important, though not necessary, to have a solid concrete floor. With regard to virgin soil, that seemed to him to be anything except absolute refuse. They might take the grass off a field and build on that, which would be virgin soil, whilst it should be law that the lowest room in a house should be built on an impervious material. Nor was the Act adequate in other respects. It provided for one watercloset in a house, but, having put that one closet in, which complied with the Act, fifty others might be put in that did not. Dr. Longstaff had referred to the necessity of having windows to more than one side of the house, and the difficulty about that had also been pointed out. He thought that, for such cases, dispensing power should be given to some one by the County Council. They should provide regulations for the ninety-nine cases that formed the rule, and not for the one

forming the exception. The difficulty he had long felt of enforcing all penalties for breaches of byelaws should be met by placing the duty of the prosecution upon the police.

Mr. W. N. Elliott, of Plymouth, considered the erection of dwellings under sanitary conditions to be the first consideration, as all enjoyment of life depended upon it, and he thoroughly approved of the means suggested for the purpose in the paper. In Plymouth, concrete beneath the floors of houses was compulsory, except the site was on a solid rock. Sanitary inspectors had to contend with the difficulty arising from the fact that insanitary buildings were often the property of members of the local authority, and great influence was brought to bear upon the officials of the borough, interfering with the exercise of their duty in a conscientious manner. If these inspectors were independent men, and were paid from an independent source, the results would be more satisfactory. Then if the expense of erecting healthy dwellings for the poor was really so great that their inhabitants could not pay the rent, he did not see why State aid should not be granted. Some of the speakers had confined their remarks to London, but in an International Congress they had to deal with all towns.

Dr. Sykes called attention to the fact that the title of the paper was the "Control of the Construction of *Buildings*," not *dwellings* only. He laid stress upon this point because he wished to mention something that bore materially on that question. Buildings were inhabited or uninhabited. Uninhabited buildings affected the health of the population only by external influences, while inhabited buildings affected it externally and internally. Those who were acquainted with English legislation would last year have seen an Act,—the Public Health Amendment Act,—in which there was a clause introducing a totally new feature into the building legislation. The clause was to the effect that any building that had not been erected for the purpose of a dwelling should not be used as a dwelling until permission had been obtained for its being so used from the surveyor or architect of the district. A building might be erected which was not intended to be dwelt in, and yet be used as a dwelling-house, whilst, *vice versâ*, a dwelling-house might be converted to other uses. It was through this conversion that the whole difficulty in building legislation arose, and he hoped that the County Council would adopt measures for preventing a stable-loft,—he was going to say a kennel,—being used as a dwelling without being rendered fit for habitation. He spoke from personal experience as a medical officer of health.

Mr. E. T. Brydges, Town Clerk of Cheltenham, wished to point out with reference to the remarks made by Dr. Sykes about the Public Health Amendment Act, that that Act was an adoptive Act, which had the serious defect that one could not adopt sections of it, and, for that reason, local authorities had, in many cases, not been able to avail themselves of it. He agreed that byelaws should apply to all houses irrespective of date of erection, and that any unhealthy house should be pulled down.

Mr. H. H. Collins desired to protest against over-legislation. That the Building Act required some remodelling, one could admit. But as it had been 36 years in operation without having given rise to serious complaints, notwithstanding the serious alteration of circumstances, he thought that spoke well for the Act and for those who had framed it.

On Furnishing Steam from Central Districts for Heating and Power in Towns and Cities.

BY

S. M. BURROUGHS.

As water, gas, and electricity have been found most convenient and economical when supplied to the general public from central sources, the idea was suggested, and has been found practicable in its working, of supplying steam from mains laid under the streets from which it can be conveyed either for heating purposes or for power. The first practical experiment in this direction was made by Mr. Holly, of Lockport, New York, the inventor of the Holly system of large pumping engines. The system is very simple. It consists of boilers in central stations supplied with smokeless furnaces adapted to the consumption of coal-dust, which would otherwise be wasted. The steam is conducted through the streets in large mains composed of wrought iron lap-welded pipes. Contraction and expansion are duly provided for by means of service variators which have secured unlockable joints. The pipes are covered with non-conducting substances which prevent the radiation of heat. This can be secured by covering the pipes with magnesia or asbestos, and enclosing them in logs of wood with holes bored to suit. The steam can be supplied at a high pressure, say at 80 pounds, and can then also be used for driving engines, pumping water, &c., &c. By means of reducing valves the pressure can be reduced to 3 pounds on the square inch; and by the use of steam meters, the quantity of steam taken by each customer can be measured. The New York Steam Company now furnish steam for 600 engines from one station. They also supply heat for the city Post Office, the Western Union Telegraph building, and for many other buildings. Their profits are rather more than 33⅓ per cent., and their customers find this method of heating more economical and desirable than any other. Heat is supplied by this system the same as water or gas; it is on tap, and can be had at any time, day or night, by simply turning a valve. While there have been killed in New York in one year, by horse-cars 64, by waggons 55, by gas 23, by electric current 5, not a single case of death has occurred through the use of steam by this system. Mr. F. H. Prentiss, the chief engineer and general manager, gives the following affidavit:—"I am chief engineer and general manager of "the New York Steam Company, and have been in the employ of said "company and familiar with its affairs for seven years. There has never "been an explosion of a steam-pipe of this company in the streets of "New York; there has never been a paving stone lifted, to my "knowledge, except by a crow-bar, in the usual way. All talk of "explosions in this connexion is supreme nonsense. The sudden "generation of force necessary to prodnce an explosion, which can and "does take place in a steam boiler, cannot occur in the street pipes. I "state, as an engineer and expert in steam matters, that such a thing is

" physically impossible, as there is no fire under the pipes in the streets. " They are as safe and free from explosion as Croton Water pipes."

There is abundant evidence, not only in New York city but in other places where this system has been employed, to prove that it has given general satisfaction, and to indicate that there is a future of great usefulness before it. It can be utilised with great advantage by electric lighting companies, because they can employ their waste steam for the purpose. The Edison Electric Company of Kansas City paid the cost of the investment from the first year's income. The system is especially useful for college buildings, asylums, &c. The mains should be laid down from 4 to 6 feet underground. No man-holes are necessary; the variators should be placed about 50 or 100 feet apart, and should be enclosed with brick. The pipes enter buildings through a cellar or basement, and connect with radiators wherever required. The condensed steam is usually conducted into the basement, where it passes through coils exposed to a current of fresh air from the outside; this abstracts from the steam the remaining heat and then passes upward into the rooms where required for heat and ventilation. The water is of course also pure, and can be used for general household purposes; or, if not required, can be passed into the sewer. If steam is required for heating water, it can be easily carried into a little gravel at the bottom of a basin or tub. The steam can also be used conveniently in drying rooms for drying clothes; it can also be used for forcing water upstairs to tanks by means of steam pressure; also for green-houses and conservatories; and likewise for cooking. It is a great protection against fire, because, if steam is turned into any room where there is a fire it speedily extinguishes it. The risk of fire is greatly reduced by the employment of such a system. The loss of heat, when the main pipes are well covered, is considered to be not more than 5 per cent. The system has been found economical, and has been adopted in competition with good coal at $2\frac{1}{2}$ dollars per ton. A few of the advantages are, briefly; *First*, convenience; *Second*, absence of fireplaces and stoves, and of the risks attendant upon them; *Third*, uniformity of temperature is easily secured; *Fourth*, absence of dust, smoke, and noxious gases which come from coal, gas, or petroleum; *Five*, economy; *Six*, absence of danger from explosions, economy of labour over the use of separate boilers; utility over supplying the steam for power.

In 1891 the Holly system was in use in 29 towns in the United States; also for heating power in different buildings in these towns. The adoption of such a system would, I should think be particularly desirable in London, and might be the means of abolishing the smoke and fog nuisance. It has been found that the value of land along streets where the steam mains are laid has been considerably increased thereby. If therefore, the supply of steam should be taken in hand by municipal authorities, a considerable amount of the cost could justly be defrayed by taxing the increased values imparted to adjacent land by the laying down of steam-mains.

DISCUSSION.

Mr. R. A. Robinson said he was glad that Mr. Burroughs had brought the idea of this improvement to London. He saw no reason why the plan could not be carried out, to judge by the evidence adduced by the lecturer. He would like to know, however, how far steam could be carried. Another point was that our streets were already filled up with underground pipes, and he had some hesitation in advocating the insertion of more pipes than were absolutely necessary. He would like, however, to see the system tried, as it would be of great importance to London.

Mr. John Atha (Leeds) pointed out that, through conducting steam in pipes underground for long distances, part of the steam would be condensed into water, and thus in a short time interfere with the proper working of the system.

Mr. Burroughs, replying to various queries, said that the size of the pipes depended upon the demand. The main would have to be large, perhaps 8 in. or 9 in., but much smaller pipes would convey the steam into the houses. He had not heard of the subsidence of the soil causing any serious difficulty, but they were in the same position as with water and gas. So far the scheme had been carried out with great satisfaction in the United States, and it has also been found that it tends to an improvement in the sanitary condition of the towns. As to the collection of condensed water, there were traps provided into which such water would fall.

Wednesday, 12th August 1891.

The President, Sir ARTHUR BLOMFIELD, in the Chair.

Sur la Constitution Hygiènique des Murs d'Habitation.

PAR

M. le Prof. EMILE TRÉLAT, Directeur de l'Ecole Spéciale d'Architecture, Député de la Seine.

Les murs des habitations modernes sont toujours exclusivement établis en conséquence de deux idées fondamentales :—1°. Une idée techique qui porte à rechercher des matériaux capables de durer dans le temps, de résister aux charges mécaniques auxquelles ils seront soumis dans la construction et de fournir à la perspective de l'édifice des ressources plastiques en rapport avec l'expression architecturale désirée ; 2°. Une idée économique qui porte à rechercher des matériaux faciles à travailler et peu coûteux à obtenir.

Il faut ajouter que dans les villes qui s'étendent sans cesse et absorbent de plus en plus les populations des campagnes, l'espace manque au constructeur, ce qui lui commande de réduire la place occupée par les *pleins* de ses édifices. Les murs doivent donc y être aussi minces que possible. Ils sont aujourd'hui d'autant plus minces

que les villes sont plus populeuses et l'habitation plus dense. Comme d'ailleurs, les constructions à la campagne prennent de plus en plus modèle sur celles des cités, on peut dire d'une manière générale que la tendance actuelle du constructeur est de réduire l'épaisseur des murs.

Je voudrais fixer l'attention de la Section sur les conséquences de la routine que je viens de décrire et montrer qu'il y a nécessité de faire intervenir dans le problême des considérations absolument négligées aujourd'hui.

Pour cela il faut envisager le mur de maison, non plus seulement comme un organe de la construction, mais comme un facteur du bien-être et de la salubrité intérieure. C'est, en effet, entre les murs qui enclosent nos logements que doivent être aménagés le confort et la sécurité de l'habitation. A ce point de vue les murs sont, d'abord, pour l'habitant des parois de protection contre les intempéries : pluies, vents, écarts et excès de températures atmosphériques. Ils sont, en second lieu, des intermédiaires qui doivent favoriser autant que possible la reconstitution de la salubrité intérieure sans cesse compromise par le fonctionnement de la vie pendant que les locaux sont habités.

On infère facilement de ces conditions de service des murs la nécessité de définir leurs capacités :—1°. Au point de vue de la protection qu'ils fourniront à l'intérieur contre les *variations* atmosphériques ; 2°. Au point de vue de leur influence sur l'état atmosphérique intérieur.

I.—*Capacités des murs au point de vue de la protection qu'ils doivent assurer à l'intérieur contre les variations atmosphériques.*

Les variations atmosphériques sont *mécaniques*, *hygrométriques*, ou *thermiques*.

Les variations *mécaniques* sont dûes aux mouvements de l'atmosphère qui est calme ou venteuse ou tempêtueuse. Les murs, comme on les construit couramment, sont toujours des protecteurs suffisant à ces sortes de désordres. Il n'y a pas à s'en occuper ici.

Les variations *hygrométriques* sont tributaires des saisons, des climats et des sites. L'atmosphère est alternativement sèche ou humide, et ces alternatives sont plus ou moins souvent répetées selon les localités. Un intérieur sain ne supporte par ces changements d'états. L'atmosphère doit y être convenablement chargée d'eau : ni trop sèche, ni trop humide. Les variations extérieures ne doivent pas sensiblement l'influencer. On voit intervenir ici non seulement une question. d'épaisseur de parois, mais une question de constitution matérielle de ces parois. En laissant de côté l'épaisseur qui est généralement suffisante dans la pratique courante, on constate, que certains matériaux de construction donnent très facilement passage à l'eau, tandis que d'autres l'interceptent complètement. Les grès, notamment ceux de formation tertiaire, comme les *grès de Fontainebleau*, sont dans e premier cas. Un morceau de grès de Fontainbleau, d'une épaisseur très notable (50 ou 60 centimètres) en contact avec l'eau sur une de ces faces, laisse voyager le liquide dans ses profondeurs et atteindre après

quelques heures la face opposée. Au contraire, du granite ou du calcaire placés dans les mêmes conditions ne se laisseront pas sensiblement pénétrer par l'eau. On peut dire qu'au *point de vue hygrométrigue* la conservation d'une atmosphère intérieure saine demande des parois composées de *matériaux imperméables à l'eau.* Les variations *thermiques* extérieures dépendent encore des climats, des saisons et des sites, qui gardent les nuages au ciel ou qui les en éloignent. Les surfaces du sol et de ses reliefs sont influencés par l'état thermique de l'atmosphère; et, quand celui-ci persiste, les échauffements au les refroidissements de ces surfaces pénètrent dans les profondeurs.

Une parois d'habitation est un protecteur effectif contre les changements de température quand elle arrête dans son corps, sans le laisser traverser, les variations thermiques auxquelles est soumise sa face extérieure; en d'autres termes, quand elle est pourvue d'une suffisante capacité d'isolement. Le type d'une semblable paroi pourrait se définir ainsi :—Elle serait composée d'une matière assez isolante et elle serait assez épaisse pour que les écarts de température extérieure n'eussent jamais le temps d'atteindre les profondeurs de l'ouvrage jusqu'à gagner la face intérieure. Les échauffements et les refroidissements du mur s'opéreraient ainsi sans modifier l'état thermique de la surface intérieure qui enveloppe les habitants et agit constamment sur eux par rayonnement. Une semblable paroi dans nos latitudes, entre le 42° et le 52°, degré, devrait avoir 2^{m} et plus d'épaisseur. On trouvait de pareilles conditions dans les vieilles constructions de l'antiquité et du moyen-âge. Il était alors facile d'entretenir dans l'habitation une régularité de température sensiblement constante. La surface intérieure des murs ne subissait que de légers écarts de chaleur auxquels on remédiait sans peine, à l'aide de simples foyers de cheminées. Nous sommes aujourd'hui très éloignés de conditions aussi favorables avec l'épaisseur réduite de nos murs. La face intérieure s'en refroidit considérablement l'hiver et s'échauffe de même l'été, en sorte qu'elle rayonne offensivement sur nos corps du froid ou du chaud. Pour remédier à cet inconvénient les appareils les plus divers sont employés au chauffage pendant la saison froide et nous en tirons peu de satisfaction en général; tandis que nous sommes dépourvus de palliatifs pendant la saison chaude.

C'est contre ce double mal qu'il faudrait réagir en donnant plus d'épaisseur à nos murs d'habitations. A Paris et dans la France du Nord les constructeurs donnent aux murs de facade une épaisseur de 0.50^{c}. quand on les construit en pierres calcaires, et de 0.35^{c}. quand on les onstruit en briques. La brique (argile cuite) possède une propriété d'isolement sensiblement double de celle du calcaire, si bien que le mur cde briques de $0^{m}.35$ est plus protecteur contre les changements de tem pérature que le mur de calcaire de $0^{m}.50^{c}$. Ces épaisseurs sont, toutefois, insuffisantes l'une et l'autre. On peut, il est vrai, augmenter singulièrement le pouvoir isolant du mur en l'habillant à l'intérieur d'une doublure en bois ou en étoffe. Le bois est quinze fois plus isolant que le calcaire et sept fois plus isolant que la brique. La laine est vingt-trois fois plus isolante que le calcaire et onze fois plus isolante que la brique. On pourrait donc doubler la capacité d'isolement des murs que nous construisons avec un revêtement intérieur *en bois* de 0.07^{c}, d'épaisseur pour les murs de

calcaire, de 0.m05 pour les murs de briques; avec un revêtement intérieur *en étoffe de laine* de 0m·5 pour les murs de calcaire, de 0 025 pour les murs de briques. Sans prétendre à d'aussi beaux résultats, on voit le parti qu'on peut tirer des matériaux fortement isolants, pour améliorer les murs de face de nos maisons. Quoique ces doublures isolantes soient des remèdes coûteux et restés jusqu'à présent des applications de luxe, c'est à elles qu'il faut recourir si l'on veut remédier à l'insuffisance de protection que nos murs nous fournissent contre les variations thermiques de l'atmosphère. *Tous nos murs de façade devraient être lambrissés en bois.* On obtiendrait ainsi, sur les parois exposées aux intempéries une garantie très efficace qui rendrait beaucoup moins pénible l'habitation d'été, et beaucoup plus facile l'entretien pendant l'hiver de la température des enveloppes rayonnantes des salles.

Je place ici une observation que je ne saurais omettre, puisque je parle à Londres et que mes auditeurs sont, en majorité, des Anglais. La capitale de d'Angleterre n'est plus aujourd'hui ce quelle était il y a une trentaine d'années encore, une ville à petites maisons basses, à laquelle s'appliquerait sans réserve tout ce qui vient d'être dit. Après s'être étendue en surface jusqu'à occuper 32,000 hectares, la ville de Londres semble aujourd'hui se ramasser sur elle même, en même temps qu'elle perce les vieux quartiers et se fait des voies nouvelles. Et comme tout se fait vigoureusement et quelquefois excessivement dans ce grand pays, on y voit s'élever des maisons à une hauteur extraordinaire. On en rencontre qui ont jusqu'à 13 et 14 étages, ce qui porte leurs murs à 35 ou 40 mètres de hauteur. Dans ces conditions la stabilité a exigé l'épaississement des murs; et, sans qu'ils le fassent exprès, on voit ainsi les architectes anglais construire des maisons dont les logements sont mieux protégés que ceux des anciennes constructions contre les changements de température. Cette observation n'enlève rien à la netteté du principle de salubrité qui commande à l'habitation d'être close par des murs permettant de maintenir aisément en température sensiblement constante les surfaces intérieures des parois.

II. *Capacités des murs au point de vue de leur influence sur l'état atmosphérique intérieur.*

Toutes les émanations du corps sont délétères. Quand nous vivons en plein air nous échappons à leur influence, soit par ce que nous ne séjournons pas au voisinage des dépôts excrémentiels que nous créons; soit parceque nos déplacements nous éloignent des lieux de l'atmosphère viciés par nos expirations ou nos transpirations; soit, enfin, lorsque nous restons stationnaires, parceque les mouvements de l'atmosphère ou les simples courant verticaux entretenus autour de nous par notre chaleur corporelle déplacent et remplacent les gaz expirés par nos poumons. Mais aussitôt que nous nous enfermons dans nos habitations nous perdons ces bienfaits. L'atmosphère limitée qui nous entoure s'infecte dangereusement si nous ne la renouvelons pas. Malgré les intempéries ce renouvellement s'opère partiellement par les fissures de nos fenêtres et de nos portes, par les vasistas et surtout par les cheminées que nous prenons soin de ménager dans chaque pièce habitée.

Mais tout cela ne suffit pas à maintenir nos corps dans un milieu de salubrité comparable à celui que nous trouvons dehors. Aussi nous efforçons-nous judicieusement, d'ouvrir nos fenêtres aussitôt que le temps le permet, ou que le voisinage bruyant et poussièreux des voies urbaines nous y autorise. Mais dans les longues saisons d'inclémence atmosphérique nous n'ouvrons pas nos fenêtres, nous fermons nos vasistas et notre atmosphère intérieure reste misérable, souvent sensiblement infectée et toujours insensiblement malsaine. Dans maintes circonstances l'infection reste pour ainsi dire collée aux murs. Cela arrive toujours dans un milieu constamment occupé pendant longtemps lorsque les murs ne sont pas *poreux*, c'est à dire perméables à l'air. Au contraire, si les murs sont perméables à l'air, l'infection de surface murale ne se produit pas. Cette perméabilité est une condition de salubrité très précieuse. Il faut la rechercher toujours.

Nous connaissons des matériaux qui se laissent très facilement penétrer par l'air à travers des épaisseurs très considérables. Ainsi se montre le calcaire tendre dont le type peut être pris dans le calcaire grossier du bassin du Paris, qu'on nomme *Vergelé*. Un mur de Vergelé de $1^{m} \cdot 00$ d'épaisseur, et plus, laisse passer une notable quantité d'air ou de gaz quelconque. Si on considère une salle habitée, close par un pareil mur, voici ce qui se passe ; l'air extérieur y voyage de dehors en dedans, tandis que l'air intérieur y voyage de dedans en dehors. Ce dernier charrie avec lui les fumiers* humides et gazeux résultant de la vie enfermée. La rencontre de ces deux courants, réducteur et réductible, produit l'oxydation des fumiers et ruine leur action nocive. Il se fait là une véritable épuration tout à fait comparable à celle qu'on obtient sur un champ poreux et perméable arrosé par des eaux d'égout courant en rigoles. On sait avec quelle perfection et quelle rapidité toutes les oxydations salutaires s'opèrent en ce merveilleux laboratoire de salubrité. Les calcaires poreux sont des matériaux très précieux pour la constitution hygiénique des parois d'habitations. Quoique leur porosité les rende facilement pénétrables à l'air, ils laissent difficilement passage à l'eau ; et, sous ce rapport, ils gardent l'avantage des matériaux qui ne laissent pas entrer les eaux atmosphériques dans l'habitation. Aussi doit-on, au point de vue hygiénique, les préférer à tous autres matériaux, aux matériaux perméables comme le grès qui ont l'inconvénient de se laisser pénétrer par l'eau, et qui, alors ne permettent plus à l'air de passer, et aux matériaux comme le granite qui, imperméables à l'eau, ne laissent jamais passer d'air.

Je dois conclure, à la suite de cette communication, par ces trois indications :—

1°. Les murs extérieurs de nos habitations sont aujourd'hui pourvus de capacités isolantes trop faibles pour que nous puissions *régulièrement* entretenir dans nos logements la température normale de salubrité.

2°. Il y a lieu d'accroître ces capacités soit en augmentant l'épaisseur des murs, soit, à défaut de cette augmentation, en

* Mot très juste et très pittoresque du Dr. Rochard.

révêtissant la face intérieure des murs d'une doublure faite en matériaux très isolants, tels que le bois ou les étoffes.

3°. Au point de vue de la pureté atmosphérique intérieure, les meilleures parois sont les murs composés de matériaux perméables à l'air et imperméables à l'eau. Le type de ces matériaux est le calcaire tendre.

DISCUSSION.

Professor T. v. Gruber (Vienna) will nicht den geistreichen Darstellungen des Vorredners widersprechen, macht aber darauf aufmerksam, dass ein sehr grosser Theil der Wände durch die Fenster eingenommen wird, die hier in England wie in Frankreich nicht nur in höchst anerkennenswerther Weise sehr gross, sondern auch stets einfach gemacht sind. Die Wärmetransmission durch das Glas ist aber bedeutend grösser als die durch das Mauerwerk; so lange also nach climatischen Verhältnissen einfache Fenster genügen, erscheint eine Verstärkung der Mauern-Ende nicht nöthig; vortheilhaft ist es aber gewiss, und besonders unter climatischen Verhältnissen, welche die Verdoppelung der Fenster verlangen, in die Mauern "Lichtschichten" als schlechte Wärmeleiter einzuschalten. Wir dürfen nie übersehen, dass wir die Anforderungen der Hygienie nicht zu hoch ansehen, wenn wir den grössten Bedürfnissen der Gegenwart, der Schaffung von entsprechenden Wohnungen für die arme Bevölkerung, Rechnung tragen wollen. Was die Permeabilität der Wände betrifft, ist wohl zu unterscheiden in welcher Weise die Ventilations-Einrichtungen durchgeführt sind. Wo für die Vorwärmung der Beleuchtung und für entsprechende Abzugsschlote vorgesorgt ist, und die richtige Ausnützung dieser Einrichtungen erwartet werden darf, ist es gewiss am besten die Aussenwand der Mauer permeable, die Innerwand aber inpermeable zu gestalten. Wo aber die richtige Verwerthung der Ventilations-Einrichtungen nicht zu erwarten ist, muss man leider noch heute vielfach diese bedauerliche Thatsache constatiren, dort wird die Permeabilität der Innenwände und Mauern das Richtige sein.

Dr. Spottiswoode Cameron (Leeds) thought that there was a danger, in excluding damp, of excluding another precious element, the oxygenating influence of fresh air, which largely took place through the permeability of walls. In many houses the means of ventilation were almost *nil*, but a certain amount of the deleterious gases got out through the walls. Was there not a danger, if we made the walls too impervious, that we might be doing as much harm as good?

Mr. Ralph Nevill, F.S.A., did not agree with Mr. Seddon in his observations on a previous paper in favour of solid walls rather than hollow walls. To make the walls impervious by increasing their thickness was useless, so long as in other parts of a room there was only a single pane of glass between the inmates and the open air. He was of opinion that windows should always be constructed in such a way that there should be an air space always between two sheets of glass forming the windows.

Mr. H. H. Statham said he was disposed to agree with the last speaker, that it was of no use to increase the thickness of walls while we had glass windows occupying so large an area of wall space. In

England we were not accustomed to double sheets of glass, with an ½ in. air space between.

Mr. H. H. Collins said that Pettenkofer gave instances of houses for the working classes built of iron slag, which was supposed to be impermeable. But such houses were found to be extremely uninhabitable, because, at certain seasons, water would be found running down the interior walls. The speaker agreed with Mr. Neville with regard to hollow walls, and, he would add, hollow windows.

Mr. W. P. Buchan (Glasgow) said he doubted whether the double window with ½ in. or 1 in. interspace would prove as effective as some of them anticipated. He knew a church in Glasgow where the windows were double and of large size, in which the cold was bitterly complained of. He was of opinion that experiments should be made in the period of winter to ascertain the proper interval between two sheets of glass in order to prevent the escape of heat. Half an inch appeared to him too little. The most effective interval was probably between ½ in. and 1½ ins., or, perhaps, 2 ins. It would be a great advantage to have the matter settled by careful experiment.

M. Trélat, in replying on the discussion, said he had guessed, rather than understood, the drift of the arguments. The speakers appeared to be of opinion that the loss of heat by windows would be so great as to neutralise the advantage of thickened walls. It was a question of degree, of calculation, of volume. The larger the windows the thicker should be the walls. The fundamental idea was that the surrounding mass should be so ample and sufficient that the heating of a wall should not depend upon the withdrawal from the inmates of any portion of their animal heat. He hoped that his remarks would not be misunderstood by his ancient colleague and general secretary at Vienna, the Chevalier Von Gruber.

Sur l'Emploie des Fondations sur Pilotis pour les Habitations.

PAR

le Dr. P. J. H. Cuypers,
Architecte des Musées Nationaux, Amsterdam.

I. Les constructions datant du moyen-âge dans les villes construites dans un terrain marécageux, comme Amsterdam et Rotterdam, sont toutes bâtis sur pilotis. De ces temps on augmentait la résistance du sol tourbeux en enfonçant grand nombre de pilotis long de quatre mètres environ, tout côte à côte. Toute cette masse de bois était enfoncée jusqu'au dessous du niveau de l'eau; sa surface était beaucoup plus étandue que la largeur des fondations en maçonnerie. L'élasticité des couches tourbeuses comprimées par les bois de sapin, agissant dans un même sens que la force de l'eau dans lequel ces bois sont enfoncés, constituaient la résistance pour la fondation des constructions.

À mesure que les moyens méchaniques, servant à forcer les bois de sapin à entrer dans le sol, se sont développés, on a augmenté la longueur des bois, pour atteindre plus de résistance. Dans beaucoup d'endroits on est parvenu à un systême (reposant) basé sur un principe plus sur:

restreindre le nombre des pilotis, augmenter leur force en choissant des bois de plus forte dimension, les enfoncer en terre jusque dans les couches très résistantes de sable pur, ou mêlé d'argile. Dans ces conditions il est possible de calculer la force résistante de chaque arbre qu'on vient d'enfoncer, puisque le poids du marteau, la vitesse avec laquelle il frappe la tête de l'arbre (pilotis) et le poids de l'arbre sont connus ; et après chaque coup l'on mesure l'avancement en terre. Dans certains cas la résistance d'un arbre peut être évaluée à dix-huit mille kilogrammes. Dans certains endroits la couche originelle de sable déposé par la mer ou les fleuves, est si profonde que les plus forts arbres (de vingt mètres par exemple), n'atteignent point ces couches résistantes.

II. Le niveau de l'eau qui enpreigne le sol, est dans tous les terrains tourbeux (généralement des polders draînés par les moulins à vent ou pompes à vapeur) assez constant de hauteur. On a retrouvé des fondations en pilotis d'anciens monuments ou des ramparts des villes après plus de deux ou trois cents ans, qui étaient restées tout à fait intactes quant à leur résistance. Le bois s'était noirci, et était aussi dur que le métal.

Dans les "polders" qui existent déjà plusieurs siècles, les terrains se sont retrécis, et on a dû abaisser le niveau constant de l'eau. Des suites très funestes se sont déclarées dans les monuments datant de plusieurs siècles. Les fondations ne résistaient plus, et des crévaces se montraient de tout côtés. L'examen des pilotis démontrait que le bois avait été à sec, et était donc pourri en peu de temps. On a pu y remédier dans quelques cas, en coupant les bouts des pilotis pourris et en introduisant par morceaux, de la maçonnerie entre les vieux murs et la fondation en bois d'autant plus profonde.

III. On pose les pilotis en moyenne à une distance de 0.50 m. mesurée sur les centres. En coupant et égalisant les têtes des arbres enfoncés on ménage un tenon qui entre dans les traverses (holl.=*kespen*), destinées à supporter le plancher en bois (épaisseur de 0.08 à 0.12 M, en sapin ou en chêne là ou le poids de la construction sera très grande). Les différentes planches sont posées à une distance de 1 à 2 centimètre pour leur permettre de se dilater sous l'influence de l'eau, sans exercer une pression dangereuse sur les moyens d'assemblages surtout des planches extérieures.

IV. Les ingénieurs du "Waterstaat" (Ponts et chaussées, etc.), et de chemins de fer de l'état ont quelquesfois coulés des blocs immenses de bêton en ciment, comme moyen de relier les têtes des pilotis, et en même temps comme fondations pour les maçonneries. Les pilotis avancent dans ce cas sur un mêtre en hauteur dans la masse de bêton, qui a deux mètre de hauteur ; comme ces fondations sont exposées à une très grande pression par la structure superposée (des piles de ponts en fer, etc.), il faut pouvoir conter absoluement sur la cohésion du bloc de béton, afin qu'il n'y pas de danger qu'il se rompe, en plusieurs pièces ; un écroulement de l'œuvre entière en pourrait être la suite funeste.

Aussi en vue de quelques désastres qui se font produits dans des constructions exécutées d'après ce systême dans des terrains marécageux

et très peu résistants, les architectes n'ont pas imité ce systême qui n'est efficace, que dans des terrains sablonneux et argileux, formés par les couches des grands fleuves ; dans ces conditions ou peut éviter avec le pilotis des constructions pneumatiques bien plus couteuses.

Quoique le béton pourait fournir une bonne fondation pour les caves, qui serait imperméable à l'eau du sol, on ne l'employe pas dans ce but, craignant les fissures, dans les terrains marécageux ; les fondations entièrement construites en bois sont absoluement nécessaires dans ces circonstances, pour porter la maçonnerie.

V. Depuis deux siècles la coutûme d'habiter les caves, de les destiner pour les comptoirs et bureaux des commerçants, pour des ateliers de peintres et verriers, de menuisiers, etc., s'était extrêmement répandue dans nos grandes villes, à cause du prix élevé des terrains et des fondations. Un grand nombre de la classe ouvrière vivaient dans de caves en grande partie sous-sol. Et comme les fondations n'avaient pas été executés avec assez de soin l'eau pénétrait pendant l'automne et l'hiver, souvent au dessus du pavé. Chaque soir et chaque matin ces habitants pompaient devant leur entrée cet eau, pour l'éloigner par les égouts, pour un certain temps du moins. Car chaque jour elle revenait de nouveau.

Depuis vingt ans les autorités communales, ont défendu d'habiter les sous-sols, et ceux qui les habitaient dans ce temps, devraient les quitter dans un espace de temps déterminé.

Quoique à présent les cas soient rares que les sous-terrains soient encore habités par des familles entières, pourtant on dispose généralement la cuisine et quelques autres pièces, qui sont habitées pendant le jour dans les sous-terrains. En tout cas il est d'une grande importance pour la salubrité des habitations, que les caves soient absoluement sêches. L'humidité des planchers et des murs ne ferait pas seulement pourir les bois, les meubles et les tapisseris, etc., dans ces sous-terrains, mais dans un pays aussi fièrreux, que le nôtre, les habitants sentiraient bientôt les suites funestes d'une demeure, où cette humidité se répandrait par tous les étages.

Les conditions suivantes s'imposent à la structure de nos caves, sur une fondation en pilotis.

1°. Comme le bois ne résiste pas à la décomposition, au dessus du niveau de l'eau, les murs en maçonnerie sont posés au dessous du niveau de l'eau le plus bas, qui se présente. Pendant l'exécution des maçonneries on tient le puit, dans lequel on travaille à sec par de pompes de différentes capacités.

2°. Pourque garantir le plancher de la cave, ou du souterrain, on peut le monter au dessus du niveau de l'eau dans de sol. Afin de guarantir les murs d'agir comme conducteurs de l'humidité, une partie comprise entre deux plans horizontaux : l'un en dessous du plancher intérieur, l'autre en dessus du sol environnant, est exécuté en chaud hydraulique, au ciment, ou à la chaud melangée de parties égales de ciment de tuffeau (pièrre de tuffe provenant des boids du Rhin, écrasée en poussière).

Les évaporations du sol sont écartées par des courants d'air introduits au dessous du plancher, passant sur une couche de sable couvrant le sol originaire.

3°. Dans le cas ordinaire, voulant économiser sur la hauteur de la construction, on est bien obligé de descendre le plancher du sous-terrain en dessous du niveau de l'eau. Il faut que le pavement, aussi bien que les murs, jusqu'en dessus du terrain environnant, soit parfaitement imperméable. Comme on ne construit en général, que des murs d'une dimension très faible, il faut gagner en qualité des briques et du mortier, ce qu'on perd de force par les faibles épaisseurs des murs environnants.

Trois à quatres couches de briques très bien cuites et dures, sans les moindres crévasses, posées dans un mortier de chaud et ciment, suffisent à résister à la pression de l'eau, qui ne vient d'une hauteur trop grande. Le dallage en marbre blanc ou en dalles de grés cérames est posé en dessus. De même les murs qui auront 0.34 m. à 0.45 m. d'épaisseur (tout suffisants pour porter trois étages), ne résistent pas à la pénétration de l'eau par les joints horizontaux des assises. Il est donc nécessaire de les courir à l'intérieur avec les mêmes couches de briques très dures, posées à plat (dans la plan vertical) jusqu'à la hauteur du niveau du terrain environnant). On prend bien soin de poser les briques en couches successives de manière que les joints soient toujours couverts par les couches supérieurs.

Mais comment supporter les dallages dans un terrain aussi marécageux?

(α.) Quand le bâtiment possède dans sa fondation plusieurs murs parallèls peu distancés, la construction de voûtes cilindriques est facille et préferable. Le peu de hauteur nécessaire pour la voûte ne causera pas de difficulté dans le niveau du sous-terrain. Sur toute la superficie de la voûte ou coule du beton, où l'on remplit les profondeurs en maçonnerie afin d'égaliser la surface dans un plan horizontal, sur lequel trois ou quatre couches de briques avec le dallage forment un unsemble bien résistant à l'eau et les évaporations humides du sol. La surface extérieure des murs est couverte d'asphalte coulant, afin de prémunir les murs dans toute leur épaisseur contre la pression de l'eau.

(β.) Supposons que le sous-terrain ne possèdent que des pièces assez large, les fondations des murs restent bien espacées, de plus de 3 mètres. En ce cas les voutes cilindriques exigent une hauteur considérable sous le pavé. On préferre donc de continuer le plancher en bois sur toute la surface du bâtiment, afin de se passer des voûtes, et de pouvoir continuer la maçonnerie hydraulique des fondations, non seulement sous les murs, mais sous la surface entière de l'habitation. Tout ce bloc est exécuté dans les meilleurs matériaux, les briques les plus dures, etc.

Sous les couches de briques, sur le plancher en bois, une couche d'asphalte toute unie, guarantit d'avantage contre l'action de l'eau, surtout à cette profondeur où l'eau veut remonter avec force dans la maçonnerie.

Les différentes couches de briques font parfois remplacées par un beton au ciment, couvert d'une couche de ciment en mortier (moitié sable) d'une épaisseur de 3 centimètres au moins. Cette couche de ciment doit être continuée contre les murs jusqu'à la hauteur du terrain.

Les caves ainsi construites sont parfaitement saines ; les influences de l'humidité du terrain, entièrement empreigné d'eau bourbeuse ne s'y font pas sentir du tout. Ces caves préservent toute la demeure de l'humidité dans les voisinages où le soir et la nuit des vapeurs désagréables puissent s'évaporer du sol.

4°. Si le cas présente qu'une habitation, construite il y a longtemps, ne possède pas de caves convenables ; et que les fondations ne sont pas assez larges pour y installer encore la construction décrite plus haut ; on exécute tout la cave dans une enveloppe de bois, de la forme d'un grand bac, posé à l'hauteur voulue, pendant qu'on tient l'eau pour ce temps à un niveau plus bas. Même sans fondations ces caves avec un grand massif de maçonnerie ne s'enfoncent pas dans le terrain marécageux, parceque le volume de l'eau remplacée est plus grand que le poid de toute la cave, comme elle a intérieurement un grand vide. Ces sortes de "caves flottantes" montent et baissent avec le niveau de l'eau entre les murs de la maison, et sont retenues par celles-ci dans leur direction.

VI.—Plusieurs habitations dans les villes de la Hollande sont situées sur les bords de l'eau, sans quai intermédiare. La salubrité de ces maisons ne diffère en aucune sorte des autres maisons des mêmes villes, pourvu que les fondations soient exécutées avec soin : car au fond, toutes les maisons de ces mêmes villes ont leurs fondations également sous la surface de l'eau, sans que les inhabitants en ressentent aucune suite désagreable ou malsaine.

Dans le bois de sapin et de chêne, sur dans les longs arbres de sapins, nous avons donc trouvé de matériaux d'une très grand valeur pour la construction dans tous les mauvais terrains. Le bois, qui dans la nature a comparativement si peu de résistance, ne pourrait être remplacé dans ces conditions par aucune autre espèce de matériaux.

Si la Hollande ne possède en général que peu de terrain solide à bâtir, puisque les provinces du Nord sont formées par un alluvium marécageux, elle a trouvé dans le bois de sapin, qui fournit des arbres d'une longueur assez considérable et de dimensions assez fortes, le moyen d'aller trouver le sol naturel à des profondeurs qui diffèrent de 4 à 28 mètres.

Une partie de la gare centrale à Amsterdam, notamment les piles extérieures de la charpente de la couverture sur les voies, a exigé des pilotis de 28 mètres de long sur une épaisseur de 38 à 40 centimètres à une mètre du tronc. La construction des fondations en maçonnerie de ce bâtiment, qui à 318 mètres de long sur 31 mètres de largeur a été établie sur un pilotis continu sur toute l'étendue du bâtiment. Les arbres sont enfoncés sur 50 centimètres d'axe en axe et assemblés par des madriers en chêne de 20 sur 30 centimètres et croisés par des longerinnes également en chêne de mêmes dimensions.

The Sanitation of Theatres.

BY

LENNOX BROWNE, F.R.C.S., Ed.

When the committee of this section did me the honour to permit me to embody in a paper the information I possessed of the condition of our theatres, I felt it was desirable, notwithstanding the long and extensive experience of them that I had, that a careful and detailed examination of the principal buildings should be effected in order that any statements I might find it my duty to make, should be founded on exact and precise information.

Through the courtesy of the lessees and managers, I have been able, in conjunction with my friend Mr. Ernest Turner, F.R.I.B.A., to inspect no less than 20 of our London theatres, besides a number in the provinces. I had, indeed, made application to 22 metropolitan lessees, but in two instances, instead of the ready assent accorded me by the majority, I was met by peremptory refusal, on the ground that the lessees could not permit their theatres to be inspected, except, to quote the exact words of the secretary of one, "by the authorised authorities."

As to one of these theatres, its pent-up situation, its age—over 30 years—and its manifold sanitary imperfections in the front part of the house, may be taken as sufficient reasons for the objections to inspection of the back; but with regard to the other, I had hoped to be able to describe it as a theatre which, being one of the most recently erected, might be accepted as a type of what a small comedy theatre should be, in the same way as one is able to point to another as a type of all that is best suited for the home of grand opera, and to a third as an almost ideal theatre for the requirements of light comic opera. However, during a visit to the front, when I occupied a seat in the stalls, on the prompt side, a strong whiff of carbolic acid which assailed my nostrils each time the door to that portion of the auditorium opened, indicated that the condition of the urinal in the adjacent lobby was far from perfect; and I further learned that another similar convenience opens directly into the pit; so one may assume that however well the building is constructed with an eye to the beautiful, and with all modern improvements for scenic display, the sanitary arrangements have not been equally successful in conception, or, it may be, in execution.

Of the 20 theatres which I did visit, it may be said at the outset that in many the arrangements, from a sanitary point of view, are the reverse of satisfactory; indeed, there is hardly one in which some fault may not be detected. But I am bound to testify that the defects are for the most part due to structural causes for which, when existing as part of an original plan, I am sure every member of this section will agree, that there is no excuse, although the blame should rest rather with the architect than with the proprietor. On the other hand, I have

the greatest pleasure in bearing witness that the managers have, with hardly an exception, endeavoured to overcome the difficulties of the situation by care and supervision. If they have not always been successful, it has been far less often from want of zeal on their part than from the ignorance and neglect characteristic of members of the lower branches of the theatrical profession, and especially of the working staff, who represent, for the most part, a low type of the artizan class. Against the results, however, of bad workmanship in the sanitary fittings, no amount of supervision of the employés is of much avail, and unfortunately in theatres, as in our own houses, instances of slip-shod and faulty work are by no means exceptional.

In the front of the house, among the audience, it is found that from the careless way in which sanitary appliances are used, they are not unfrequently getting out of order, or giving cause for complaint. With a large section of the public, and not by any means those occupying the cheaper seats, it would seem necessary to supply automatic flushers, or a staff of attendants specially to wait on them.

Most of our investigations were made on Sundays, for two reasons —1. Because it was the only day on which we could give the time necessary, and was the one least likely to interfere with the working of the theatre. 2. Because on that day, better than on a week day, one could gauge with a certain degree of accuracy, the care that was bestowed on the household arrangements generally; for as a straw may show which way the wind blows, so such small matters as leaving the slops unemptied till the Monday may be taken as a criterion of the ordinary practice in regard to sanitary matters.

Another indication of no small value of the sort of sanitary care that is taken at a theatre is afforded by the arrangements for the removal of dust and rubbish accumulation. At several, all dust is removed daily; at others, not only in small or in provincial theatres but in some of the largest London houses, heaps of refuse may be found, not at one, but in many corners.

I have not thought it necessary to make analyses of the air in these buildings, as I had at first intended, partly because this matter has been very carefully gone into by Angus-Smith and others, but chiefly because, given the cubic space, the number of occupants and of gas lights, and the amount, or rather, too often, the want of, ventilation, deductions can be drawn sufficiently convincing as to the state of the air, without calling in the aid of the analytical chemist.

Much has been written on the duty of theatre proprietors to afford protection from the risk of fire or of alarms of fire; but the London County Council, in its elaborate requirements in this direction, seems to have almost ignored the far more important subject of the health, not only of the actors and actresses, but also of the general public. I say "more important" advisedly, as there is ample evidence to show that the time when fires are most liable to occur in theatres, is not when the house is full, but within two or three hours after the audience and company have left the building; whereas if the sanitary arrangements are faulty, the danger is a constant one; and this danger to health,

while affecting the audience, must much more affect those employed behind the scenes, because they are compelled to be in the theatre for much longer periods, both for acting and rehearsals, and are there all the week round. Moreover, it is behind the scenes that insanitary conditions are to be found in their most objectionable form; and although from time to time more or less fitful interest has been excited by the rumour of a death or of a severe illness taken by some member of a London or a country company, any systematic sanitary investigation of that portion of the building in which the actor is specially engaged has not only been completely neglected, but its necessity has been practically overlooked. It is to this department, therefore, that I have made inquiry; and since my professional work for the last quarter of a century has brought me so directly into relation with members of the theatrical profession in all its branches, I can speak of the effect on their health with no uncertainty. Nor is this merely a question of affections of the throat, although they are bad enough and important enough to those with whom a sound throat is a *sine quâ non* of their vocation, for we find that the general health of the actor suffers to a very marked extent when he is compelled to breathe constantly the vitiated air of hot, crowded, unventilated, and ill-situated dressing-rooms; the lowered state of vitality predisposes him in a marked degree to bronchitis, pneumonia, phthisis, and diseases of the respiratory and circulatory organs generally, to dyspepsia, to so-called acute rheumatism—if rheumatism, and especially acute rheumatism, be not in itself a form of blood-poisoning—and to typhoid fever, deaths from which last are by no means uncommon among actors, especially in the case of members of touring companies. It is well known, also, that a craving for stimulants is set up by insanitary conditions of the respired air and surroundings of a man's work. Indeed alcohol is often asserted—it has never been proved—to be an antidote to the poison of an unsavoury atmosphere or occupation, and the statement is frequently made as an excuse for indulgence.

But it must not be supposed that because I deal with those mysterious parts of a theatre behind the curtain, that it is the employés who are the only sufferers from insanitary conditions in those situations. It must indeed have been in the experience of many that when the curtain has risen, or a scene has been changed, and especially when the stage has been opened up, a rush of air of charnel-like odour has blown into the house; while the occurrence of theatre headache, theatre diarrhœa, and even theatre sore-throat, is well recognised as the not infrequent morrow's payment for an evening's amusement. Moreover, anyone with the least knowledge of theatres must be aware that there are certain theatres throughout the kingdom which are hardly more or less than veritable death-traps.

Whenever I have conversed with a member of the theatrical profession on the subject I have always been told of one or other particular provincial theatre which was especially condemned. Not a few buildings have been particularised by more than one informant, and one or two are *always* mentioned as prominently insanitary. It is, however, almost impossible for the actor to attack this mischief because he belongs to a

profession in which supply is in excess of demand, and it is even difficult for a manager. In one case with which I am acquainted, the London manager of a company, a member of which died from typhoid fever taken in a provincial theatre, was advised by his lawyer not to insist on legal proceedings as it would greatly prejudice his having a date given him should he again desire to visit that town, and this prejudice might probably be shared by the managers of other provincial theatres who were conscious of similar sanitary shortcomings and dangers to health.*

In this connexion I may mention a case which happened in my own experience, and which throws a peculiar light on the legal view taken of our efforts to prevent disease. A young lady, who had on several occasions been under my care for attacks of sore throat of an undoubted sewer-gas type, while filling an engagement in a London theatre was directed by her manager under the terms of her agreement to play at a certain theatre in the kingdom notorious as a source of typhoid. On learning the destination of my patient I conceived it my duty to warn her of the danger to which, as one specially susceptible to the effects of foul air, she would be exposed, and I, at request, made an affidavit to that effect. The lady used my advice as a plea to release of the engagement, but when my declaration was read to one of the judges of the High Court before whom the case came, he remarked that he did not see that a medical man was called upon to give an opinion of that kind until his patient had actually suffered. Had I been examined on my affidavit I should have ventured to point out to his Lordship that the efforts of a doctor to prevent disease offer more probable chances of success than do our attempts to cure it when manifested, just the same as the best lawyer is not he who gains the largest number of successful verdicts but he who, recognising the uncertainty of the law, settles the most cases without recourse to a trial in court.

I am quite aware that in all probability my statement that an abnormally large proportion of theatrical ill-health is due to insanitation will be received with incredulity by the public, and met by opposition from the managers; such is, however, my sober conviction, and not only so, for there are certain houses, not only in the provinces, but in the metropolis, from which I am almost certain to receive as patients members of the profession who in other engagements enjoy fair health.

To come now to a consideration of the actual state of affairs existing in our theatres, I would deal first with the question of their *situation*; and this has such a strong bearing upon the construction of the building in reference to proper sanitation that it merits our most careful consideration. How many of our theatres can claim perfect isolation? But few, and only those of quite recent erection; but without isolation it is well-nigh impossible either that the risk of fire, when arising

* In the case of touring companies in the provinces there is, of course, the added danger of sanitary imperfections in the lodgings occupied; since, owing to prejudice, it is difficult in many towns to procure accommodation of the better class. Moreover, the fatigue of Sunday travelling and of constant rehearsals is apt to make individuals more "receptive" of malign influences on the health.

in the theatre, can be limited to that building, or that conflagration from contiguity can be insured against.

Nor can there be thorough, or indeed sufficient, ventilation without isolation; for where there is—as exists in several cases—some sort of open space on one or other side of the building, the changed "air" is very far from "fresh," even when mechanical aids are employed; indeed, in very many instances it is actually vitiated, being drawn from some narrow slum or back court, used, may be, as a urinal, or lumbered up with disused stage properties. I am aware, of course, of the difficulties which have existed and still exist in the way of theatres being so perfectly isolated as will be admitted by modern hygienists to be necessary. Theatres to be successful must occupy central positions, and sites in such localities are difficult and expensive to obtain. Hence we find that a large number of our theatres have been erected in pieces of ground which must have taxed the ingenuity of the architect to a considerable extent in the preparation of his plans, and in at least three instances the difficulty of available site has been met by placing the theatres below the level of the street altogether, and in such a situation as to render efficient sanitation well nigh a matter of impossibility. In an above-ground theatre, however hemmed in it may be by other buildings, space for dressing and retiring rooms may be adequate or not, and windows are at least feasible, though they are by no means the rule; but in underground theatres and in rooms built under the stage windows are either altogether absent or are of the order of a transparent ceiling, and of no practical value for ventilation. Moreover, in underground theatres there must be a constant difficulty with the drainage, where, as has actually been the case, the drains are placed at a lower level than the main sewer. It is fair to report that in two such buildings of this class attempts more or less successful have been made to remedy this grave defect, a defect one would hardly expect to find in theatres built so recently, for one dates from 1882 the other from 1874; this last was reconstructed entirely for causes of sanitation in 1883. It is difficult to acquit the architect of blame in the first instance, for with all respect to the profession, I do not think he should have consented to prepare plans on such lines. Even now such an event as percolation of sewage from an old brick drain is not an unknown occurrence under the stage in one of these reconstructed sub-soil theatres. To demonstrate still further the difficulties met with in theatres built in cramped positions, I found it not an unusual position for waterclosets to be in dressing-rooms or in hot lobbies (80° F. on Sunday morning) into which dressing-rooms opened, the only means of ventilation for the closets was into these rooms (Diagrams 7, 8, and 10).* It is well nigh impossible to conceive that these arrangements were part of the original plans. While on this subject I would point to another accompaniment which I consider objectionable in underground as in all theatres, and that is having other buildings, as restaurants, erected over or in close contiguity to them.

* The diagrams referred to are given in Mr. Ernest Turner's paper which follows this one.

Applying this matter of situation to country theatres, it may be added that not only is there less excuse on account of cost for non-isolation, but that, as a matter of fact, very many of such buildings—full of other sanitary defects—cannot have this particular fault of over-crowding charged against them.

Accommodation.—Theatres which have been built during the last 10 years show improvements in the dressing-room accommodation (Diagrams 1 and 2) over that provided in the older theatres; but much still remains to be done, and in only one can the arrangement be considered absolutely satisfactory (Diagram 1). In the very old theatres, especially the large ones, there are long underground rooms without either light or water. In one of the oldest we found a room employed for office purposes placed over a vault in which were three waterclosets used by the working staff, all out of order, and in two of them the pans were full. At this theatre the fire-watch is the most complete in London, so that it is guarded against the only possibility of improving its sanitary defects; if it should take fire it is to be hoped that it will be empty, as there would be very little chance for its safety, and with its wooden staircases and numerous passages, not much for those engaged on the stage. In most theatres, even in some of the larger houses, there is an absence of a master key by which all the rooms could be opened without delay in case of fire. This defect does not exist in the case of two of the large houses visited. At one theatre we were informed that we could not enter several of the rooms occupied by principals because the rooms were locked and the keys taken away by their occupants. Such a statement can, however, be hardly credited.

While on this point of fire-watch it may be remarked that at not a few theatres the fireman is a sort of ornamental appendage to the front of the house, and very ready to call a cab or run a message. I commend this circumstance to the attention of fire insurance managers and to the successor of Captain Shaw.

In some five or six of the later built or reconstructed houses, there is good dressing-room accommodation, with sufficient air-space, ventilation, and light for the occupants. In some there is enforced permanent window and over door ventilation (Diagram 3), in others mechanical means are employed. In hardly any of the theatres of more than five years' duration is there a constant supply of water to be found in the dressing-rooms; on the other hand, where arrangements for running water obtain, there also the basins were of good class and well-trapped.

But in another class of houses things are not in so satisfactory a condition. I refer to those places which were originally not intended for theatres, but were built as music or lecture halls, and have been since adapted to the purposes of comic opera or spectacular burlesque. The original requirements in regard to dressing-rooms were naturally not at all on a par with those of a theatre. All that was needed were a few small rooms to be occupied by one or two artistes at a time who came in "turn" and would take the room vacated by those who had preceded them; consequently, when it was proposed to give spectacular entertainments the accommodation was found to be

most incomplete, and where additional houses could not be acquired, room was found below the stage.

In one such theatre we discovered 15 or 16 rooms below the stage, some even at a second level, and in only three of these were there windows. In the case of two, I was informed, and for all I know in that of the third, these windows were of necessity kept shut because they opened into areas with grating coverings through which the staff and others were in the habit of urinating. One of these rooms measured $38' \times 7' \times 7'\ 9''$ (Diagram 4), and was occupied by 16 to 18 ladies, each of whom, therefore, supposing there were only 16 occupants, had barely over 130 cubic feet of space, enough to supply them with air, if it was originally pure for about $2\frac{1}{2}$ minutes according to the estimate of 3,000 per hour; and the space given for each individual, which should include that for dressing-table, dresses, &c., would be something like 16 square feet, or an area of 4 feet by 4.

Another instance of imperfect accommodation is represented by the theatre originally constructed for the purposes of comedy with a small company, but later employed for production of comic opera with a company four, or it may be six, times as numerous. In this description of theatre, adapted from buildings not originally intended for dramatic representation, we found, and I regret to say in many others, closets either in or close to the rooms (Diagrams 5, 6, 7, 8, 9, and 10), separated in some instances only by a partition of match-boarding (Diagram 6).

The old pan closet has been retained even in one house otherwise well nigh perfect, and a closet much advertised was repeatedly pointed out to us as the acme of completeness, albeit it is one which sanitarians generally would consider far behind the requirements of to-day. In one theatre a w.c. adjoined the dressing-room of a principal artist, and the fatal error was permitted of having the closet disused, though the cistern for the drinking water and a sink were situated in the same cabinet. Nor was it at all uncommon, when we came on a closet particularly badly situated, to be told, as a virtue of management, that it had long been disused. Needless to say, no one in these cases had thought it necessary to cut off connexion. Nor are the w.c.'s in the front of the house any better than, or, for the most part as good, as the majority of those at the back, and for the defects in their situation and for the utter absence of all ventilation the architects must surely be held responsible. In some instances it would appear as if no arrangement for such necessaries had been part of their original design, for we found them literally planted in such positions that the only source for fresh air (save the mark) or for exit of foul was an adjacent cloak-room, lobby, refreshment-room, or even a portion of the auditorium. That this statement is not exaggerated is proved by the plentiful dissemination of the odour of disinfectants, and, in fact, whenever a disinfectant is to be smelt, it may be accepted that it represents, not the antidote, but the disguise of a poison it has attempted to conceal by a more vigorous attack on our olfactory sense.

On the programmes of a newly reconstructed theatre the particular form of disinfectant employed in the building is naively printed under the advertisement of the special musical organ used. In another, in

which we found a w.c. in the ladies' cloak-room ventilating onto the staircase, and a second onto the passage lobby to the stalls, we were met in all parts of the building by a printed certificate of a recent date, and signed by a gentleman who added "F.S.I." to his name that "the "sanitary condition before and behind the curtain was (in his opinion) "*satisfactory*."

I have alluded to an instance in which a w.c. behind the stage was contiguous to the flue of a restaurant under which the theatre was built. In another theatre a closet in the front of the house, which was indeed a part of the ladies' cloak-room, was similarly overheated, and no means of cooling existed except by opening the door which led to the passage for occupants of the boxes and stalls. The accommodation of this nature, even to Royal boxes, in more than one instance is faulty.

So much for the closets. I regret to say that the condition, and especially the situation of the urinals behind the stage, are even worse. Sometimes there are none whatever for the working staff, so that accommodation is often sought for either against the walls and down the areas of the theatres themselves or at the adjoining "public."

In one of the earlier theatres that we visited, where, as was well known, many members of the company had been recently ill, we found a stand-up urinal situated beneath the stage at the back and centre. Openings in the stage flooring really exposed the urinal to view, and these openings were in point of fact the main sources for its ventilation. We should have hesitated to mention a circumstance so damnatory, and, as it might appear, so identifying of a particular theatre, were it an isolated example, but I regret to say that we found the same condition with but slight, and in no sense extenuating variations, in several other houses.

In one, the urinal of the working staff was in the corner of the stage itself; the ventilation was, however, not entirely on to the stage but into a fire-escape shaft, whence windows opened on to each half-landing of the staircase used by the company; how much of the malodorous air of this urinal was drawn from these windows into the dressing-rooms and how much driven on to the stage by down draft of cold would be a nice (?) point to determine.

Incidentally reference has been made to the extremely deficient ventilation of the working portion of most theatres. It is a pleasure to state that at two houses, where very large numbers of dancers, &c., are gathered in one room and have to make many changes of dress, the construction of the rooms and the ventilation—which is of a permanent character—are well nigh as perfect as they can be. In the smaller rooms of these theatres occupied by the "principals," especially when they are foreigners, every inlet for fresh or outlet for used air is carefully and almost hermetically blocked.

Lighting.—The electric light is now largely used behind the stage, but is often supplemented by gas burners because the artistes—quite erroneously, as is proved by their absence in the Royal English Opera House and the Savoy—insist that the electric current cannot supply sufficient heat for their purposes of "make up."

Heating.—The absence of ventilation entails such an excessive temperature that the thought of any method of warming seems hardly to have occupied the mind of the theatrical architect of the past, and except in the green room, it is rare to find a fireplace in use in rooms behind the scenes, or even to find one at all. An excellent coil arrangement exists in one of the most recently built houses.

The foregoing remarks represent in almost the fewest possible words the outcome of our inspection; it is needless to add that a paper could have been written on any one of the many headings considered, and almost on any one of the theatres, which should have occupied the limit permitted to the whole. But, in point of fact, I have been able to take but a general survey, and perhaps this is as well in an opening paper, and I have therefore asked Mr. Ernest Turner to utilize a large quantity of the information we obtained as a separate contribution to this discussion, and have had pleasure in placing at his disposal the rough sketch plans made by me at our visits for the purpose of diagrammatic illustration.

I fear that my communication will be considered as representing a pessimistic view. From the aspect of the doctor it could hardly be otherwise; for in making a diagnosis one has rather to take note of what is diseased than of what is sound. But in making a prognosis one is permitted to place in the balance both the favourable and the unfavourable; and, so doing, I venture to prophesy a greatly improved sanitary condition of our theatres in the near future. Nor would I wish it to go forth that in my opinion the sanitation of theatres is any worse, except that large numbers of persons are occupied therein for a constancy of employment, than is that of concert halls, conventicles, or institutions for the purpose of Christian association.

In conclusion, I may say that one of the conditions which I imposed on myself when undertaking this inquiry, was that my remarks should be as impersonal as possible. While, therefore, I have been careful not to actually identify any theatre whose arrangements I have felt it my duty to condemn, I have been obliged to abstain from naming those possessing characteristics which it has been a pleasure to commend.

Diagrams Illustrative of the Sanitation of Theatres.

BY

Ernest Turner, F.R.I.B.A., Architect to the Royal Academy of Music.

The diagrams exhibited, 12 in number, are complementary to Mr. Lennox Browne's paper, and, although they are not measured drawings to scale, but only proximate representations as to size, they are accurate in so far as they illustrate types of good and bad arrangements at the theatres visited.

In considering the matter fairly, it must be borne in mind that the buildings represented are of very different dates, and the strong contrast

which is presented between those of earlier and those of later date marks well the progress of sanitation, and will, I think, lead to the conclusion that many of the older theatres require their sanitary arrangements to be remodelled, amounting, in some instances, to an entire reconstruction of a portion of the buildings.

Diagrams Nos. 1, 2, and 3 illustrate three arrangements of dressing-rooms in relation to corridors and conveniences, the first two constituting part of the original plan of the theatre, the third, the arrangement in an added house.

No. 1 represents the dressing-rooms on each floor in one of the newest London theatres, and is in every way well planned. The corridor is well lighted, and cross ventilation is practicable when desired;

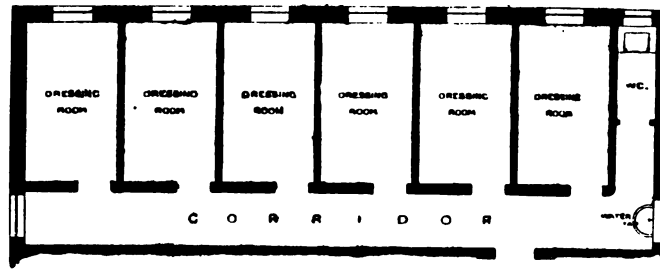

FIG. 1.

the closet is well placed; the rooms are sufficiently large and lofty and have good windows opening to the public street. The well-arranged presses and lockers with which the rooms are fitted, affording a place for everything and security against loss, render it practicable to leave the doors of the rooms open when unoccupied, although, strange to say, advantage is not taken of such facility in the very theatre under consideration.

This latter point appears to me to be worth more consideration than it generally receives, both on the score of access for the fireman and of air flushing the apartments.

There are in this theatre several floors of dressing-rooms similarly arranged; and a hydraulic lift, which travels at high speed, conveys the performers to and from the stage. The perfection which has been attained in the construction and mechanism of lifts or elevators may be the key to the problem of providing adequate dressing-room accommodation upon what might otherwise appear to be inadequate sites.

No. 2.—Here the closets are placed at the ends of the corridors, and one over the other, not an unusual arrangement in modern theatres, but necessitating at least a good air shaft, which is not generally to be found, but does exist in this house.

In many theatres it is difficult to believe that the closets formed part of the original plan of the architect, indeed, to the professional eye, there is strong evidence that they have been added as afterthoughts.

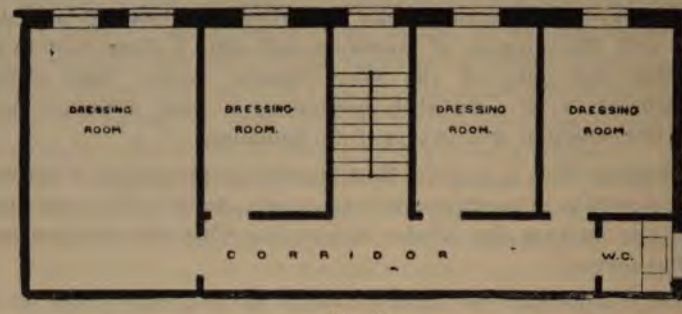

FIG. 2.

No. 3.—Although the dressing-rooms here are good, the corridor is only lighted by artificial light, and it is ill-ventilated. It may be thought that, as the buildings are chiefly occupied at night, the absence of windows in the corridors is of little importance. A visit to the theatres, and the difference that will be observed between the cleanliness and sweetness of corridors lighted naturally and artificially will soon

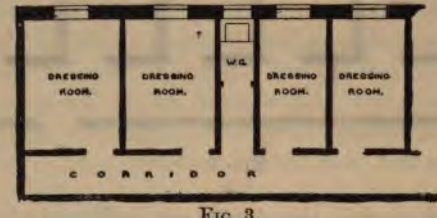

FIG. 3.

dispel such illusion. And whilst on the subject of cleanliness in corridors and elsewhere, let me draw attention to the many advantages which arise from the use of glazed bricks as internal wall surfaces. In a few of the modern theatres they have been freely used with most satisfactory results.

Nos. 4 and 5 represent two of the worst dressing-rooms seen by us. No. 4 is occupied by 16 to 18 girls, who have to remain the greater portion of the evening in this room, which is under the stage, and

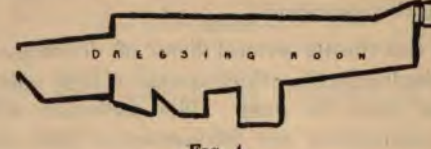

FIG. 4.

FIG. 5.

practically unventilated. Having regard to the small amount of cubic space, the number of lights and occupants, and the impossibility of air

renewal, such an arrangement must be condemned as highly insanitary. Indeed, it is nothing short of gross cruelty to compel human beings to occupy such a den.

No. 5 is another cellar dressing-room, in the same theatre, with piers and vaulted roof, almost, if not quite, as bad as the last, and has, in addition, a closet and sink in objectionable proximity. The legal definition of a "cellar dwelling" is "an underground room in which "any person passes the night," and it is illegal to occupy such room unless certain regulations as to height from floor to ceiling, size and position of window, means of ventilation, &c., are complied with. These cellar dressing-rooms do not in any way comply with such regulations; but it appears that they may be occupied from 6 o'clock until 12, although occupation from 12 to 6 would be illegal.

Turning for a moment from examples of bad arrangement, it is a pleasure to be able to speak of two metropolitan theatres where, in some of the dressing-rooms used in common by a large number of dancers and supers, there is not only ample cubic space in the large and lofty rooms, but excellent natural and artificial ventilation.

Diagrams Nos. 6, 7, 8, 9, and 10 illustrate faulty arrangements of closets in relation to dressing-rooms.

In No. 6, which is a portion of an added house, the closets on two stories are practically portions of the dressing-rooms, enclosed by match-boarding partitions only. One, which was very defective and offensive,

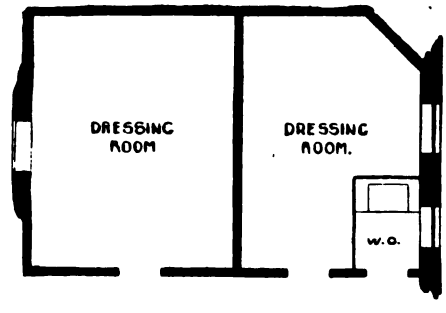

FIG. 6.

was for the accommodation of about 30 people, and was partitioned off from a dressing-room 15 ft. × 10 ft. × 8 ft. high, occupied by three ladies. This arrangement reminds me of one lately found *in* the kitchen of an Italian restaurant in London, where the only convenience was enclosed by a canvas screen.

No. 7 shows an exceedingly bad arrangement of unventilated lobby, dressing-rooms, and closet. The air of the latter pervades these rooms and the lobby, and to intensify the evil, the heat from the boilers of an adjoining restaurant renders this unsavoury corner almost unbearable. It is true that each dressing-room has a window, but each window opens into a very deep and narrow area common to the restuarant above, and covered by a grating with small openings.

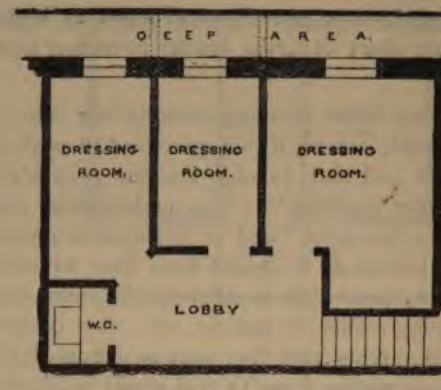

FIG. 7.

No. 8 illustrates an underground closet in connexion with dressing-rooms (occupied by four of the principal gentlemen of the company) and with staircase close to the stage; being without window to the open air, it necessarily pollutes the atmosphere of adjacent room, staircase,

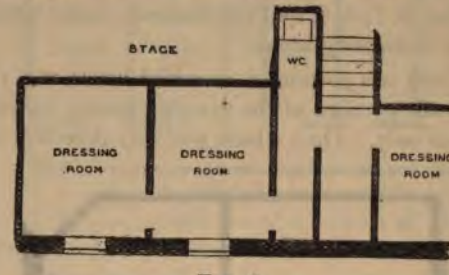

FIG. 8.

and lobby, and all the more so since, with the idea of ventilation, a small square opening has been made through the wall on to the staircase in question.

No. 9 shows another closet in the same theatre, again without window, open to the staircase and adjoining dressing-room, and situated under the cistern for drinking water, the draw off being in the

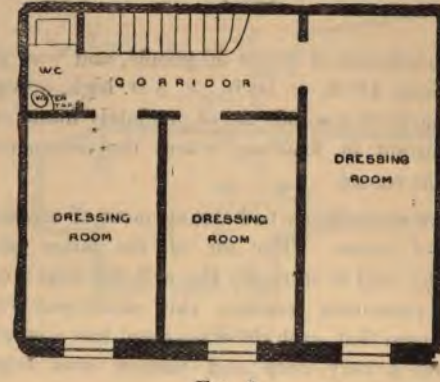

FIG. 9.

closet itself. This place, I was told, had been found so objectionable that, at the request of the occupant of the dressing-room, orders had been given that it was not to be used. No means had, however, been taken to cut off the connexion with the drain, and I need not explain to this section the probable result of the order.

No. 10 is an arrangement of closets good enough if they had windows opening into the open air, instead of, as is the fact, being

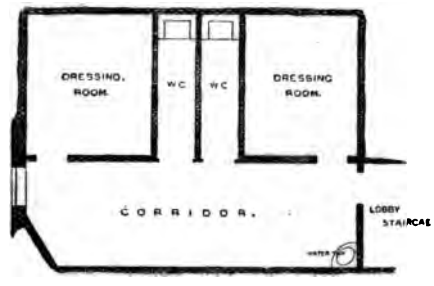

FIG. 10.

without windows, and being open to the internal lobby over the door-heads.

No. 11 illustrates an unventilated closet in relation to a private box, showing what luxury is provided for those who can afford to pay for it;

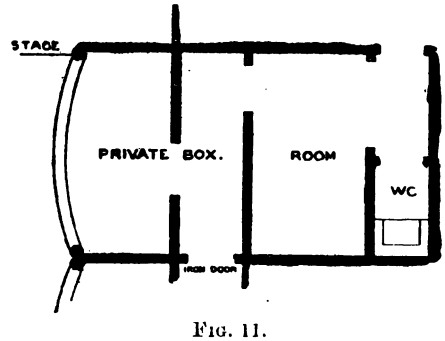

FIG. 11.

and No. 12, the arrangement of a ladies' cloak-room, this last being typical rather than unique.

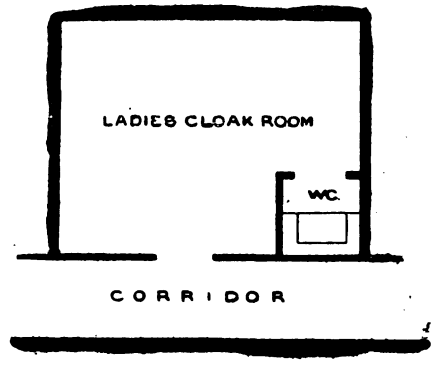

FIG. 12.

In these few brief notes I have put some of the facts plainly before you, and I have confined my remarks almost entirely to the *plan* of the apartments mentioned, the plan of the building being, from an architect's point of view, of primary importance, for, if this be imperfect, no subsequent so-called "sanitary engineering," however skilful, can make amends for the original defect.

I do not for a moment mean to imply that the introduction of modern appliances, good plumbers' work, and well-laid and ventilated drains, would not do much to improve the sanitary condition of many theatres; but, on the other hand, I feel sure that you will agree with me that many of the rooms are, from their position and surroundings, totally unfit for the uses they are put to, and that they call for abolition, re-arrangement, or re-construction.

With respect to overcrowding, one great difficulty seems to be that theatres built to accommodate small comedy companies are subsequently occupied by large companies playing burlesque and comic opera. It is obvious that whatever skill the architect may display in the original plan, and whatever control may be exercised in the official examination and approval thereof, are, in these circumstances, rendered nugatory.

In questions affecting the health of the community at large, or any particular sections thereof, Acts of Parliament and regulations are, doubtless, to a certain extent, necessary; but still more useful will be a widespread knowledge of hygiene—an appreciation of its economy and of the benefits it confers upon those who follow its teachings—a knowledge which it is the main object of this Congress in its various sections to promote.

It should be needless to say that it is solely in this spirit that my colleague and I have conducted these somewhat delicate investigations. We gratefully recognise in the general consent of managers to our request to be allowed to visit their theatres, a desire on their part to march with the sanitary enlightment of our days, and on this account, as well as from the evidences of improved construction in each new theatre which is opened, we may look hopefully to the future. We can but trust that this discussion will hasten the new era, and that the work of this section, and of the whole Congress, will help to bring the world at large to recognise that good sanitation, so long obstructed and regarded as a bore, is indeed a boon and a blessing free of hindrance or disguise.

DISCUSSION.

Dr. Allan (Public Health Medical Society) referred to the case of a theatre recently built, where, next to the box-office, and, doubtless, in close proximity to the place where the cakes and the refreshments were placed, the watercloset and lavatory were situated. In the Bayreuth Theatre they had an excellent model to follow. It stood clear in its own space of ground, and all conveniences and other buildings were quite clear of the main buildings. There was great room for improvement in concert halls, and in some of the clubs. The ventilation in most of them was bad, and they would do well to follow the example of Dr. Lennox Browne and Mr. Ernest Turner, and track down the evils to their source and origin.

If the London County Council would add to its self-imposed censorship on the morality of theatres and music halls the duty of securing proper sanitary arrangements, and would insist on a clear space around the main building in all such cases, they would be really benefiting the community.

Mr. Walter Emden complained that while in foreign countries theatres and places of amusement were subsidised, in England they were penalised, and everybody tried to stop them. He thought those who expended their money in the business were as much entitled to the benefit of the protection of the law as other members of the community, and that they should not be harassed. He contended that isolation was not absolutely necessary. A more scientific treatment of sites would enable architects to obtain all the desirable security without insisting upon the necessity of isolation. With regard to the portions of some theatres below the ground level, the speaker contended that the placing of one tier underground was not only not injurious, but was positively advantageous. If a panic of fire occurred in a theatre it would surely be better to have to come down two staircases than four. A better division could hardly be found than commencing the main staircase at the level of the street, with the pit below, and the upper circle and galleries above. Since ventilation would necessarily be effected from the top of the building, the placing of one tier below would make no difference. The heat in theatres was made a ground of complaint. Of course it was hot in a theatre, as it was in any crowd whatever. If in the building of a theatre they tried to please everybody, there would be no building at all.

Mons. F. Bouhon, architect (Member of the Commission on Unhealthy Dwellings, Paris), said he was astonished at not having heard any resolutions presented by the readers of the papers. The arrangement shown in diagram No. 4 seemed to him the most typical of what to avoid. All Frenchmen coming to London—the birthplace of sanitation—were astonished to see so many cellars used, more or less, as dwellings. Even in great and handsome buildings they saw persons living in rooms below the ground. Cellar dwellings to a Frenchman were the most intolerable things that could be imagined. After the terrible fire at the Opéra Comique, in Paris, a law had been passed of a stringent character, one of the provisions of which was that there must never be any portion of the auditorium below the ground. Let England, which had so many living-rooms and kitchens below ground, take good heed of that new law.

Dr. Dolan (Halifax) described some miserable dressing-rooms that he had seen in provincial theatres. He had in his mind one at that moment no larger than the reporters' table, in which the girls had to do all their changes and all their dressing. On one evening he was called to one of the girls who had a sprained ankle. He found no conveniences of any kind such as the circumstances required, no hot water and no cold water, except such as could be contained in a small tin can, and no conveniences for washing. The other dressing-rooms were in the same miserable condition. He had traced absolutely typhoid fever, loss of voice, and other diseases, many of them of an infectious kind, to the defective sanitation of theatres. The mills in Halifax were under regulation, and must be sanitary, and it was not too much to expect that proprietors of theatres should be under the same obligations as to sanitary provisions. Until the force of public opinion was brought to bear upon proprietors and managers of places of public amusement, the present miserable state of things would doubtless continue. He most cordially congratulated Mr. Lennox Browne and Mr. Turner on the admirable character of their papers.

Mr. Lennox Browne, on being called upon to reply to the various speakers, said he could not agree with Mr. Emden, who had said that isolation was not necessary. How could you get ventilation if there was no open space at the back? He could not follow the meaning of Mr. Emden when he said that ventilation was only possible from the top. In a theatre at Vienna there was a fan arrangement by which hot or cold air could be admitted from a valve placed under the seat, and either hot or cold air could be turned on at the will of each individual occupant.

Some Insanitary Superstitions in House-building.

BY

H. Heathcote Statham, F.R.I.B.A.

The remarks in this paper refer more especially to houses built in large and crowded cities. Houses built in open situations in the country are permeated by an atmosphere comparatively pure and clean. Houses in large towns are permeated by an atmosphere laden with impurities, which are continually being deposited on every surface that will retain or absorb them. They are also subject, unless carefully watched, to the incursion of various types of vermin, from the popular cockroach down to even more noxious and happily rarer examples. It is therefore desirable that they should be constructed of materials least likely to absorb and retain impurities, and that the method of construction should be such as to leave no unlighted and inaccessible spaces.

The habitual construction of ordinary houses in England is not in accordance with these requirements. For many generations the orthodox manner of making a house floor has been to lay wooden joists from wall to wall with boards nailed down above, and a lath and plaster ceiling beneath, the space between being an unseen cavern for the accumulation of whatever dirt and decaying matter can find its way in. What the results may be I once saw in the worst form in a case where the boards of an East End schoolroom were taken up to ascertain the condition of the joists. The space between those joists was filled nearly to the top with a festering mass of dirt and dust, over which the children had been daily collected. Such a floor would not be allowed in a modern London board school, but it is the accepted floor for a dwelling house; and though the conditions of a well-kept dwelling house do not encourage such an accumulation as this, I believe the tenants of the best kept London house which has been inhabited for any length of time would be disagreeably surprised at the amount of dirt they would find under their flooring boards if they looked for it. The old-fashioned system of ceiling up to the under side of the flooring boards and leaving the joists visible is far more sanitary; the drawback is that it is unsightly, and that it does not shut out sound sufficiently. Double flooring boards with felt between would get over the latter objection to some extent; but what I wish to recommend is the general adoption of solid floors of iron and concrete with a wood block or plain

parquet floor on them, for the average town dwelling house. They are almost necessarily adopted for houses in flats, why not for every dwelling house?

In the same way it has for many generations been the recognised faith that a house roof can only be made by means of rafters laid on the slope with a tie at the foot, and with ceiling joists either at the springing of the roof or part way up the slope. The advantage of this is that the upper rooms which go partly into the roof are rendered inconvenient and unsightly by a low sloping ceiling to half the room, and that above the ceiling joists is a dark cavern between them and the roof, into which no one ever sees, and where dirt may accumulate and vermin may breed undisturbed. It is really an almost alarming thought to reflect what is the probable cubic content of these dark caverns in the roofs of houses over all London. If it be thought necessary to go on building sloping roofs, either the whole slope of the roof should be thrown into the top rooms, as the visible ceiling, or the ceiling of the highest living rooms should be at the level of the roof springing, and the space between that and the rafters should be treated as storage space easily accessible and sufficiently lighted to be readily examined from time to time. But in fact it is entirely unnecessary, in these days of iron, and concrete, and tile, that we should build sloping roofs at all; the doing so is a mere superstition, except where reasons of architectural effect are concerned; and certainly architectural effect does not concern itself much in the ordinary house roof. With flat roofs with a cement finish and sufficient fall to run the rain to the gutters, we should get rid at once of all these dark caverns, the exterior and interior of the roof would coincide in shape, and convenience and healthfulness would be alike consulted.

The whole tribe of things called "skirtings" and "casings" are superstitions of the same kind, for providing dark inaccessible places where no cleansing hand can ever come. Baths and watercloset basins are surrounded with those foolish fences of joinery; whited sepulchres, which indeed appear neat outwardly, but within they are full of—no one knows what, for no one ever looks. Let both watercloset and bath stand open to inspection all round, instead of being cased in. In the matter of the bath, the money spent on panelled casing and "polished baywood or mahogany top" would go far to render the bath itself a neat and presentable piece of furniture.

This system of ornamental casing is carried out again in the wooden skirtings which are fixed at the base of the walls of each room. Skirtings may be considered necessary for three reasons—for appearance, for a stop to the plastering, and to prevent chairs and other articles of furniture knocking against and injuring the paper and plaster. But they should be in a solid thickness of wood of no greater projection from the plaster surface than is necessary for their practical object. Unfortunately, it is considered necessary that the larger and more dignified a room is the larger moulding and the greater projection the skirting should have. As we are not going to the expense of putting down moulded timber three inches thick round the room, a moulding of the desired projection is fixed on the top and a piece of inch-and-a-quarter wood fixed between that and the floor, with a nice hollow space

behind. The result is often rendered audible by the scuttering and scrambling of the mice, who are enjoying their gambols in the private corridors which we have obligingly provided for them.

Casings for pipes are, no doubt, necessary, and are generally specified to be screwed on, so as to be removable when required. They never are removed, or the space behind seen, except when something is wrong with a pipe. They should be hinged, and made with button fasteners, so that they can be opened every day without any trouble. Among other drawbacks, they form a private lift or elevator for the cockroach, who is fond of warmth, and is enticed to ascend along the line of the hot-water pipes. The cockroach is bad enough in the kitchen, but a good deal worse in the bedroom it is hardly worth while to afford him the luxury of a private passage, heated with hot water, to the upper floors.

The passion for sash-windows in this country leads to the employment of another system of wooden cradling built up round the windows, with hollow inaccessible boxes for the lines and weights, besides (generally speaking) another set of hollow spaces behind the back of the shutter casings. It is perfectly possible to make sash-windows without pulleys and weights in more ways than one, unless when they are very large and heavy. But the casement window has the advantage that it can be hung in solid frames without any of this bandbox work round it, and making it weather-tight is merely a matter of care and scientific construction. It is worth consideration whether we should not do better to return to it as the more wholesome and sensible structure of the two.

Another curious superstition is that windows must have curtains. The recognised principle seems to be to make windows much larger than is necessary to light the room, and then to stop out a great deal of the light by hanging curtains over them. This seems hardly either sensible or sanitary. Curtains are terrible collectors of dust and dirt. Everyone knows that a curtain that has been up three weeks in London is hardly fit to touch; and is there any reason, in the nature of things, why windows must have these draperies? Suppose we tried smaller windows, and a more decorative treatment of the frames and glazing, and left them unencumbered by curtains. We should get as much light in a more healthy and sensible, perhaps even in a more decorative manner. Think of the treatment of windows in oriental houses in Cairo and elsewhere. That could not be copied for this duller climate, nor are copies desirable; but it may afford a hint for a modification of decorative treatment of somewhat similar type.

Wall paper is a simple and inexpensive means of producing decorative effect in a room, but papers should be close in texture and smooth in surface. Papers with embossed surfaces, and, above all, what are called "flock" papers, are dust holders, and such wall surfaces cannot be kept properly clean. Coloured plaster, finished with a hard surface, is more sanitary than any paper, considering that the paper has a layer of paste behind it which becomes rotten in time. If, however, papers are renewed often enough, and the plaster stripped and well scoured at each renewal, the insanitary element in them is not of sufficient importance to counterbalance the decorative gain.

Large and deep plaster mouldings and decorations are now, fortunately, going out of fashion on æsthetic grounds; they are injurious to the cleanly condition of a house, affording so many pockets for the lodgment of dirt. As long as they are kept flat and in low relief there is no harm in them. The wooden mouldings with a hollow on the top, which are now much used to take picture-hooks, are objectionable, as the hollow is always full of dust. The old brass picture-rods are much to be preferred in this respect.

Furniture, which is a kind of minor architecture, has its superstitions of construction, the worst of which is the system of finishing large wardrobes, book-cases, &c. with a cornice standing up all round the top, leaving a wide pit for dust, which is never seen, and cannot be swept. This cornice is a mere fashion, utterly useless and absurd. The top should be made level or (still better) sloping, and with no raised ledge above it, so that it can be swept. It is best of all to make large erections of this kind as fixtures carried up to the ceiling, and finished with a moulding against the ceiling; then there is no place where dust can accumulate.

The last superstition I will mention concerns that important receptacle—the cistern. It might be supposed that the reservoir where we store our water for drinking, washing, and cooking, would be an object of some interest to the householder; that he would desire always to see and know that it is pure and clean. But it is a superstition that the cistern must not be seen; it is kept in the dark, and generally in a place which is very difficult to get at. When it is supposed that it must want cleaning, it is a business of engaging a man specially who, perhaps, has to bring a ladder to get to it. I knew a case where the water in the house began to have an evil taste, and it was found that a dead bird had been in the cistern for many days in an advanced state of putrefaction. The cistern should be in a well-lighted place, where it can be easily seen every day. The best way would be to make it as an aquarium tank is made, with a front of plate glass, so that you can see the light through the water.

To keep a town house thoroughly clean is a continual fight, not only against accumulation of dirt, but against vermin. I remember one case where a nobleman who had become tenant of a house in one of the best terraces in London, at a very large rental, brought an action for compensation against the landlord because the house was found to be full of unmentionable insects from top to bottom. This was an exceptional case, and argued great neglect on the part of someone; but it is a fact that the chances are far greater for this sort of pest in houses built with hollow floors and a great deal of woodwork than they would be with solid floors and skirtings without recesses behind them. Generally speaking, the clean and healthful condition of town houses is greatly assisted by the use of non-porous materials as far as possible, and the avoidance of all dark and inaccessible corners. The present system of building town houses is exceedingly faulty in these respects, is capable of radical improvement, and should be improved accordingly.

DISCUSSION.

Mr. H. H. Collins said, with regard to solid floors, there were other materials besides iron and concrete that might be used. Among those that might be mentioned were terra-cotta and coke-breeze. One point alluded to was worthy of special consideration. In Captain Shaw's book it had been shown that wood was not the inflammable material it was generally supposed to be. It had been found that beams 12 inches square, after the fiercest fire, stood the ordeal so well, that, if peeled, they could be used again. A floor had been patented which was composed of solid wood blocks. Such floors were not very expensive, and could be produced for 6*s*. per yard. With regard to roofs, there were climatic reasons for preferring sloping to flat roofs. In winter flat roofs would retain a great weight of snow. The casement windows recommended by Mr. Statham would be very inconvenient, particularly in small rooms with much furniture in them. He agreed with the paper with regard to skirtings, and he objected to picture rods; there was a system of picture-mouldings, which he preferred.

Colonel Prendergast said he should have liked to hear further discussion with regard to solid floors; but met, as that section was, to deal with sanitary matters, they would, perhaps, do better to try to find out how far block floorings would tell against the efficient ventilation of rooms. If there was a ventilating flue, that flue must produce a current of air, and the instant one did that in went the bundle of rags to stop the ventilation. On the question of roofs Mr. Statham had done good service. In Italy, and in the buildings of ancient Greece, flat roofs were universal. But in this country we were told we had no climate, and, therefore, flat roofs were impracticable. If Mr. Statham could solve that problem, he would do a very great service to the community. In concluding, Colonel Prendergast said he could see no reason why they should not have solid floors made of paper.

Mr. Ralph Nevill, F.R.I.B.A., said they had in Mr. Statham's paper a condemnation of boarded floors, and if the author could get all architects to follow his example he would do them a good service. It was, however, a question of cost. Six shillings a yard did not seem much for a solid floor, but in the great majority of buildings the expense would be the great obstacle to their adoption. In the ordinary boarded floor the sole object of cleaning up seemed only to be to wash dirt into the cracks of the floor with dirty soap and water. Solid block floors would be difficult to level if laid on breeze, and such floors would, he conceived, require a layer of asphalte to prevent rot. He recommended the French system of bees-waxed floors. It was a great pity we had none in England. Ladies objected to dance on solid floors, and there was the sound difficulty. The experiments made many years ago in this line of investigation by Mr. Thaddeus Hyatt were worthy of attention. The speaker differed from Mr. Statham as to flat roofs, which would be a constant source of trouble; and such an enormous amount of guttering was required with such roofs that they would be continually in want of repairs.

Mr. J. P. Seddon, F.R.I.B.A., agreed on most points with the paper. Solid floors need be no disadvantage to ventilation. Pipes to convey air should be laid, passing from the floor through to the fireplace, just as water pipes were laid. He was in accord with Mr. Statham in his jeremiad against hollows. Hollow walls were intolerable for

harbouring vermin. A very perfect and cheap wall could be made with two 4½ inch brick walls, with an inch air space. The inside joints might be left a little open, and the cavity filled in with Portland cement grouting, and the courses might be bonded by a few tie-courses being placed under or over the window. The walls thus became very solid.

Col. Seddon, R.E., referring to the passage in favour of solid floors, described arrangements adopted by him for forming of concrete the floor of a gun battery at Portsmouth. After a time it developed cracks. These he filled up with old railway iron, which, when laid in the cracks, stopped all further vibration. He had built barracks on the same kind of site, which was very irregular, having here and there pockets of soft ground, and in other places spots of hard ground. Again, he laid in the crevices pieces of railway iron, but to form the floor he employed large man-of-wars cables cut into the required lengths, crossing and re-crossing one another in all directions, and embedded in the concrete. There had been attempts to produce the same results without the use of cables, but they had always failed.

Councillor Hannam (Leeds) agreed with the suggestions for solid floors; wood blocks might be laid down for 6*s.* per yard of flooring, but this sum would be for the wood merely. The expense would always be a great difficulty in the way of the general adoption of solid floors. Concrete roofs also were very costly, and flat-roofed buildings always had an unfinished look. In the absence of high-pitched roofs, it would be necessary to carry their chimney stacks to a much greater height. They would often require to be 14 feet or 15 feet high above the square of the building, and in most cases such a height would, with only our present resources, be practically impossible.

Sir Arthur Blomfield said he once had experience of the advantage of using iron bars in the same way as had been described by Colonel Seddon. When he (the Chairman) was a much younger man, he had the task of erecting a church on a very treacherous foundation between a railway and a river. It had given him a great deal of anxiety. He had tried various devices with but little success, until he struck upon the plan of laying down iron bars near the bottom of the concrete. Since then he had observed no symptoms of further settlement.

Dr. Wilberforce Smith said the advantages in crowded districts of utilizing the roof seem indisputable if there be no associated drawback of an important kind. Those advantages are mainly—1. Economy of space.—The utilization of immense areas which at present are as unemployed as if they formed part of a remote prairie, and this in districts, *e.g.*, in London, where every square yard of land is of fabulous value. The gain represents an additional stage added to each building without increased height. 2. Economy in regard to sky space.—So far from involving any encroachment on the sky-view, the plan advocated effects in most cases a gain of sky-space if it take the place of a span-roof, and it is obvious that the human beings forming the only additional mass above the roof are insufficient by their bulk to create any appreciable set-off. 3. Purity of atmosphere.—Few persons appear to have any conception of the gain of freshness in the atmosphere at the level of the roof as compared with the street below. Such was his experience when he first read a paper on the subject at the British Medical Association in 1876, and experiments made from time to time ever since have only confirmed this experience. On the extensive roof of the Higher Grade

School in Leeds, the children enjoy an atmosphere fairly comparable with that of the moor outside the town. There is a singular misconception as to the prevalence of soot about the roof. Even for the dwellings of the wealthy there would, in some cases, be great advantage in the utilization of the roof. In his experience, the residents of South Kensington, for example, notwithstanding sanitary advantages, mostly feel every summer the relaxing effect which belongs to the lower level of their district; in such situations the fresher atmosphere of upper floors is well known, and must be experienced at its best upon the very roof. 4. Minor advantages over recreation places on the level of the street are such expansion of view as a town can aford, and the increased quiet. For the tired brain of a worker in town, it is difficult to find any wholesome refreshment so prompt as a retreat to the comparative quiet and freshness of the roof. 5. Details of construction appear to involve no practical difficulty—such is the result of somewhat extensive inquiry—but here he especially desired the opinion of architects attending the Congress. The various uses to which the roof-space has been already applied include those of playgrounds for school children, and drying-grounds for clothes. The space is equally available for cultivating plants, and as a fresh air resting place for adults.

Mr. Statham, in answer to the various speakers, said with regard to concrete floors, he had only mentioned that one method of forming solid floors, because it was the least costly, and that consideration must be kept in view. He did not positively recommend flat roofs; he only suggested them.

Four-inch Drains versus Six-inch Drains.

BY

G. M. Lawford, Assoc. M. Inst. C.E.

It is a matter of every-day occurrence to find a 6-inch pipe used for the drainage of a single house, and this size is usually made compulsory by sanitary authorities, whether metropolitan, urban, or rural.

As a house drain is frequently dry for several hours at a time, it is obvious that where pipes of this diameter are used there must be a considerable extent of surface on which sediment is deposited, and as a natural consequence, during the periods of minimum flow this deposit will decompose and foul gases will be generated. If the house-drain is properly disconnected from the main sewer, and efficiently ventilated, a large proportion of these gases will undoubtedly be carried off and liberated in the atmosphere, but the tendency of the remainder will be to move in the direction of the house by reason of the absorptive influence of the warmer air within.

The author contends that this generation of gases in the house-drain, apart from its being adverse to the principles of sanitation, is preventible, the remedy lying in the use of smaller pipes.

Taking as an example the case of an ordinary sized town house, with an average of 10 inhabitants, and allowing 30 gallons of waste water or liquid matter to be discharged per head per day, the total volume would be 300 gallons per day, and of this amount at least one-half must be reckoned as being discharged in six hours, thus giving 25 gallons per hour as the maximum flow to be provided for. To this amount must be added the rain-fall from the roof and areas which, as a rule in the case of town houses, is taken into the sewer. The superficial area to be dealt with under this heading varies from 1,000 to 10,000 square feet; taking 6,000 square feet, which is considerably in excess of the average, and allowing for $1\frac{1}{4}$ inches of rain-fall per hour (thus providing for the heaviest thunderstorms), the total volume of rain-fall to be dealt with would be 3,900 gallons per hour. The maximum hourly discharge of sewage and rain-fall combined would therefore be 3,925 gallons, or 65·4 gallons per minute, and a 4-inch pipe will discharge this amount when running full at the very flat gradient of 1 in 207·36, the velocity produced being 2·02 feet per second, which is barely sufficient to make a drain self cleansing.

As the conditions on which these figures are based are only likely to occur once or twice a year, if at all (*i.e.*, during an exceptionally severe thunderstorm), it is evident that without special arrangements for flushing, even a 4-inch drain can scarcely be made absolutely self cleansing, more particularly as the usual gradient is from 1 in 40 to 1 in 60 with a consequent increase of discharging capacity.

The author therefore considers that under ordinary circumstances a 4-inch drain is ample for an average sized house, and that a 6-inch drain is too large to be kept free from deposit, more particularly as the majority of the pipes discharging into it are three inches or less in diameter. Baths, lavatories, and sinks never have waste pipes exceeding two inches internal diameter, and it is the exception to find more than one appliance being discharged at a time. The question therefore naturally arises "How can a 2-inch pipe possibly flush and cleanse a "pipe nine times its own sectional area?"

The soil pipe is the only pipe of larger size which ever discharges at full bore, and the amount discharged at one time (two or three gallons at the most) is insufficient to make a 4-inch horizontal drain run even half full for more than a few feet.

Automatic flushing is of the greatest assistance in keeping a drain free from deposit, and should be adopted in all cases where possible, and more particularly in cases where, from the depth of the main sewer, the inclination of the house-drain exceeds 1 in 60.

A tank containing not less than 30 gallons is sufficient to cleanse a 4-inch drain by means of a 2-inch syphon and flushing pipe, and it should be placed at the extreme end or head of the drain at least six feet above the latter point.

The author maintains that by using a 4-inch drain laid at a uniform inclination not exceeding 1 in 60, aided by automatic flushing, all refuse and other matters discharged into it will be removed in the shortest time and with the minimum of deposit, and to those who say that a 4-inch drain would be choked by such extraneous objects as a duster, a medicine bottle, or a hair-brush, the saying, "a place for everything and "everything in its place" may be aptly quoted, as a house-drain cannot obviously be the proper place for a hair-brush, and the removal of such articles can be effectually provided for by making every length of drain accessible from inspection chambers.

Another argument in favour of the 4-inch pipe is the increased circulation of air in the drain, as by diminishing the sectional area of the passage, the velocity of the air current is considerably accelerated; the volume of air which has to be set in motion in order to produce circulation in a 6-inch pipe being more than double (2·24 times) the volume in a 4-inch pipe.

Gases generated in a 4-inch drain would certainly be carried away more quickly than in a 6-inch drain, apart from the fact previously stated that the possibility of the creation of such gases in a 4-inch drain is reduced to a minimum, while in a 6-inch drain their existence is an absolute certainty.

To summarise briefly, the objection to a 6-inch drain is the fact that deposits must be formed from which noxious gases are generated, with the probability of contaminating the air in the house, while the advantages of a 4-inch drain are:—

(1.) Deposit is reduced to a minimum;

(2.) Its size is ample for the discharge of the greatest amount of waste and rain water that can possibly pass into it;

(3.) When combined with automatic flushing at regular intervals, absolute cleansing is obtained; and

(4.) The increased strength of the air currents and the consequential more effectual and rapid purification of the drain.

The author would, therefore, in conclusion, urge on all sanitary authorities the advisability of reducing the sizes of house-drains as laid down in the existing byelaws and regulations, for while they all endeavour to exclude sewer gas from house-drains by means of disconnexion and ventilation, the question of its generation in the drains themselves has apparently been hitherto overlooked.

Thursday, 13th August 1891.

The President, Sir ARTHUR BLOMFIELD, in the Chair.

Étude sur les principales causes d'insalubrité des Habitations Ouvrières Parisiennes.

PAR

ÉMILE CACHEUX, Ingénieur, chargé de l'installation de la Section XI. (Habitations Ouvrières) à l'Exposition d'Économie Sociale en 1889.

Depuis longtemps on a remarqué que dans les grandes villes la mortalité varie de 16 à 50 pour cent suivant les quartiers, c'est pourquoi on y a fait de grands efforts pour détruire cette inégalité. Dès 1842, *the Society for Improving the Dwellings of the Labouring Classes* fut fondée à Londres pour tâcher de réduire la mortalité excessive que l'on observait dans les logements d'ouvriers. Grâce à ses travaux et à ceux de l'association métropolitaine, il fut bientôt démontré qu'en améliorant les petits logements on pouvait diminuer considérablement le taux de la mortalité dans les maisons modèles, et comme les résultats obtenus firent voir que les logements pouvaient être loués de façon à rémunérer convenablement le capital engagé, la spéculation s'occupa de la construction d'habitations ouvrières et elle parvint à loger les habitants de Londres, de telle sorte qu'aujourd'hui la mortalité ne dépasse pas le chiffre de 19 pour cent.

A Paris le taux moyen de la mortalité est de 24 pour cent., mais dans les quartiers excentriques il atteint 36 pour cent. Par suite, si l'on pouvait détruire les causes de mortalité qui existent dans ces quartiers de façon à y rendre le nombre des décès égal à celui qu'on observe dans les villes anglaises, on rendrait un immense service à la population parisienne.

Nous avons fait une enquête sur l'état hygiénique de plusieurs de ces quartiers et nous n'avons pas eu de peine à nous convaincre que l'influence du logement était pour beaucoup dans la mortalité élevée qui existait dans les quartiers ouvriers, c'est pourquoi, dès 1875, nous avons commencé, M. Émile Muller et moi, une campagne pour améliorer les habitations de nos travailleurs. Le succès obtenu en Alsace, par mon vénéré maître, qui construisit les Cités-Ouvrières de Mulhouse, nous engagea à persévérer dans cette voie malgré les nombreux mécomptes que nous éprouvâmes. De nombreuses personnes se joignirent à nous pour entreprendre la réforme des petits logements, parmi elles nous citerons M. Émile Trélat, qui signala au Congrès d'Hygiène de Vienne le grand inconvénient qui résulte pour les Parisiens de l'utilisation trop complète du terrain à bâtir, et il démontra que même dans les maisons les plus luxueuses la santé était compromise par le manque de lumière.

Le remède préconisé par M. Trélat est l'expropriation des maisons trop hautes et la démolition des étages trop élevés de façon à pouvoir soumettre tous les locaux d'une maison à l'action des rayons solaires. J'ai cherché à résoudre le problème du désencombrement des quartiers du centre en essayant d'attirer les ouvriers dans les arrondissements excentriques de Paris et dans les communes voisines, en mettant à leur disposition des maisons susceptibles d'être acquises par annuités.

Mon exemple a été suivi, aujourd'hui il ne reste plus de champs dans l'enceinte de Paris, et on n'y voit plus fonctionner la charrue comme du temps où j'ai commencé mes travaux. Malheureusement l'ouvrier ne se rend pas compte du dommage qu'il cause à sa santé et par suite à son avoir, en ne consacrant pas à son loyer une somme suffisante pour être logé convenablement, c'est pourquoi la spéculation ne lui fournit pas un logement à aussi bon compte que les autres choses nécessaires à la vie. Pendant longtemps les hygiénistes et les philanthropes furent obligés de lutter pour decider nos compatriotes à imiter les Anglais, mais aujourd'hui nous pouvons dire que le succès a couronné leurs efforts. En effet, l'état des habitations ouvrières parisiennes tend de plus en plus à s'améliorer, grâce aux nombreux efforts qui sont faits à cet effet. Nous sommes loin de prétendre que tous les travailleurs parisiens sont logés conformément aux lois de la morale et aux règles de l'hygiène, car pour atteindre ce but il faudrait remédier à diverses causes qui ne disparaîtront que par suite des efforts combinés de l'État, des municipalités et des particuliers. Nous avons longuement parlé, dans l'ouvrage intitulé les Habitations Ouvrières en tous pays, de ce qui pourrait être fait dans ce sens par les pouvoirs constitués et par l'initiative privée, c'est pourquoi nous ne dirons ici que quelques mots sur ce qui devrait être tenté pour propager les petits logements convenables. Tout d'abord nous croyons que l'État rendrait de grands services à la cause que nous défendons, s'il modifiait les lois relatives à la transmission de la propriété et à la gestion des petits logements. Ainsi, un des plus grands obstacles qui s'opposent à la vente par annuités de petites maisons, provient du prix élevé des droits de mutation qu'il faut payer lors de la signature du contrat de vente ; d'après nous, l'État faciliterait beaucoup l'acquisition de maisons par petits versements, s'il exigeait le montant des droits de mutation au moment de la signature de la quittance notariée libérant définitivement l'acquéreur à l'égard de son vendeur.

En ce qui concerne la gestion des petits logements les modifications législatives seraient assez nombreuses. Nous verrions, sans déplaisir, promulguer en France une loi analogue à celle qui l'a été en Belgique, et qui aurait pour objet de supprimer le privilège du propriétaire sur les meubles du petit locataire, mais qui, par contre, lui permettrait de l'expulser lorsqu'il ne tiendrait pas ses engagements et ce à l'aide d'une procédure qui ne reviendrait qu'à une quinzaine de francs. En tenant compte de cette proposition, le législateur couperait court aux abus signalés dans divers quartiers de Paris, qui consistent à forcer les propriétaires à dépenser 70 francs pour expulser des individus qui demandent de l'argent pour quitter des logements dont ils ne paient pas le loyer.

L'administration devrait également répartir les impôts de façon à ce que les petits propriétaires ne soient pas forcés de payer des contributions qui représentent jusqu'à 12 pour cent du revenu brut de leurs propriétés.

Ainsi que je l'ai plusieurs fois démontré, ce sont les charges excessives qui grèvent les petits loyers qui empêchent les capitalistes de faire des placements immobiliers, c'est pourquoi j'ai cherché à les faire diminuer le plus possible. D'après moi, les municipalités pourraient obtenir de beaux résultats en réduisant les charges qui incombent à la petite propriété ; ainsi à Paris une rue classée revient au minimum à 400 francs le mètre linéaire, tandis qu'il serait facile d'établir des rues coûtant dix fois moins pour desservir des cottages. En ce qui concerne la fourniture de l'eau potable, l'évacuation des eaux ménagères, l'enlèvement des vidanges, les frais qui y sont relatifs sont peu importants quand il s'agit de maisons à étages, mais il n'en est plus de même quand ils concernent des maisons pour une famille. Dans ce cas les charges d'une maison louée à 300 francs peuvent s'élever à plus de 40 pour cent du loyer, sans tenir compte des réparations. Ainsi le prix d'une concession d'eau de 125 litres par jour est à Paris de 128 francs par an, celui du droit d'écoulement des vidanges à l'égout de 30 francs, le nettoyage de l'égout particulier coûte de 10 à 11 francs. La valeur de ces taxes étant établie par maison, proportionnellement à leur nombre, on comprend qu'elle soit excessive pour l'habitant d'une petite maison. Dans les environs de Paris, les charges dont nous parlons sont encore plus élevées. A Vanves, par exemple, la Compagnie des eaux ne délivre pas de concession d'eau à moins de 70 francs par an, c'est pourquoi j'ai établi des citernes pour desservir plusieurs maisons. Le prix des citernes étant de 300 francs, la fourniture de l'eau revient par maison à 15 ou 20 francs.

A Saint-Denis, où l'on arrive à établir des maisons pour 2,000 francs, la Compagnie des eaux demande pour délivrer une concession 65 francs par an.

La Ville de Paris a édicté des réglements sévères concernant les logements. Nous croyons qu'elle les ferait mieux observer si elle s'adressait aux locataires au lieu de s'en prendre aux propriétaires. Ainsi quand un locataire est atteint d'une maladie infectieuse, on force le propriétaire à désinfecter le logement contaminé, par suite il perd non seulement son loyer, mais il est encore obligé de dépenser une somme double pour remettre les lieux en état d'être reloués. Si les locataires étaient rendus responsables des frais qu'ils occasionnent aux propriétaires, ils iraient se faire traiter dans des hôpitaux spéciaux dès qu'ils se ressentiraient des premières atteintes d'un mal contagieux.

La Ville de Paris accorde des secours aux malheureux qui ne peuvent payer leurs loyers. Ces secours ne sont distribués qu'aux locataires expulsés judiciairement. Il résulte de ce fait que ces derniers ne quittent plus un logement à l'amiable et qu'ils forcent le propriétaire à depenser en frais de justice le double de ce qu'accorde la municipalité.

En résumé la Ville de Paris devrait favoriser la construction de maisons pour une famille et non celle de bâtiments à étages dont un des plus graves inconvénients est d'abrégér la durée de la vie humaine.

Malgré les sommes immenses dépensées pour embellir Paris, la mortalité dans cette ville ne diminue pas sensiblement, elle est encore de 24 pour cent, tandis que dans plusieurs villes du Nord elle a été abaissée à 18 pour cent.

Action de l'Assistance Publique.—L'administration de l'assistance publique se borne à Paris, à payer les loyers de quelques familles malheureuses. Nous ne croyons pas qu'elle aurait intérêt à construire des maisons, soit pour les vendre, soit pour les louer, comme le font plusieurs administrations charitables en Belgique, mais nous estimons qu'elle rendrait service en prenant des obligations hypothécaires rapportant 4 pour cent, émises par des sociétés philanthropiques qui construisent des habitations ouvrières, telles que la Société de Passy-Auteuil par exemple.

Action des Caisses d'Épargne.—La Caisse d'Épargne de Paris n'a pas jusqu'à présent voulu suivre l'exemple donné par les Caisses d'Épargne de Lyon et de Marseille, qui ont consacré une partie de leurs réserves à provoquer la construction de petits logements convenables.

Sociétés Savantes.—Les Sociétés savantes parisiennes ne se sont pas encore occupées de chercher à résoudre les divers problèmes relatifs au chauffage, à la ventilation, à l'évacuation des vidanges des habitations ouvrières. La Société de médecine publique a beaucoup travaillé pour assainir les logements, mais elle n'a pas tenu assez compte dans ses vœux adressés aux pouvoirs publics des charges qui résultaient de ses prescriptions, c'est pourquoi elle a rencontré une certaine hostilité de la part d'un grand nombre de propriétaires de petits logements.

Action des Compagnies de Chemin de Fer.—Les Compagnies de chemin de fer ont contribué de deux façons à l'encombrement des habitations ouvrières parisiennes, savoir :—

1° en prolongeant leurs voies dans l'intérieur de la ville, ce qui amena la démolition d'un grand nombre de logements ;

2° en provoquant dans Paris l'arrivée de beaucoup de petits employés.

Les Compagnies ont tâché de remédier à cet état de choses :—

1° en créant des trains spéciaux qui transportent à bon compte les ouvriers qui habitent en dehors de Paris ;

2° en provoquant la construction de petits logements.

Un des procédés les plus efficaces consiste à prêter, comme l'ont fait les Compagnies d'Orléans et de Paris, Lyon, de l'argent au taux de 3 pour cent l'an, à des sociétés philanthropiques qui s'engagent à loger un certain nombre de leurs ouvriers.

Action des Industriels.—Les Industriels parisiens font peu de sacrifices pour loger convenablement leurs ouvriers, car la main-d'œuvre n'est pas rare à Paris, et l'organisation du travail est telle que la majeure partie des objets manufacturés sont faits avec des machines, ce qui permet d'employer des hommes n'ayant pas fait d'apprentissage spécial.

Action de la Spéculation.—La spéculation s'est occupée dans ces derniers temps de faire des petits logements convenables ; malheureuse-

ment par suite du prix élevé de revient des habitations, les logements mis à la disposition des travailleurs se composent en général de deux pièces et d'une cuisine et se louent de 300 à 500 francs suivant les quartiers. Il est donc nécessaire que la philanthropie s'occupe de la question des habitations ouvrières, jusqu'à ce que la spéculation trouve intérêt à établir des petits logements.

Dans quelques cas spéciaux des industriels ont résolu le problème de loger le travailleur, convenablement et à bon marché. Ainsi M. Fouquiau vient de commencer le lotissement de 180,000 mètres de terrain, dans le XVIII^e^ arrondissement. Il construit des maisons qui comprennent quatre pièces et il les vend moyennant une annuité dont la valeur est inférieure à celle du loyer d'un logement de surface équivalente. Son type le meilleur marché est vendu clefs en mains au prix de 6,000 francs ou moyennant le paiement comptant d'une somme de 500 francs et celui d'une annuité pendant 50 ans. La valeur de cette annuité est de 390 francs pendant les quinze premières années qui suivent la signature du contrat et de 190 francs pendant les trente-cinq autres. L'acquéreur peut se libérer par anticipation.

M. Verberckmoës a construit des maisons à étages à Clichy en opérant de la même façon que la célèbre société, *the Improved Dwellings Company*, de Londres. Il a acheté un terrain, d'une superficie d'une centaine de mille mètres, couvert de constructions dans un état déplorable qu'il commença par démolir, puis il lotit son terrain en le perçant de rues, il en donna une partie à la commune pour faire un groupe scolaire et il provoqua la construction d'une église en cédant à bas prix l'espace nécessaire. Pour amener du monde sur son terrain, M. Verberckmoës construisit cinq maisons à quatre étages qu'il divisa en petits logements et qu'il loua de façon à retirer un revenu de 4 pour cent net de son capital engagé. Les maisons étant constamment occupées, M. Verberckmoës chercha à augmenter l'importance de ses opérations en s'adressant au Crédit Foncier, mais cet établissement ne put lui être d'aucun secours, car d'une part il prête de l'argent au taux de 4·5 pour cent et d'autre part il n'avance sur hypothèque que le tiers du prix de revient d'une maison destinée à loger les ouvriers. Plusieurs autres établissements de crédit immobilier ayant refusé de consentir à prêter de l'argent à des conditions plus avantageuses que le Crédit Foncier, M. Verberckmoës s'adressa au public pour trouver l'argent nécessaire à l'utilisation de ses terrains. A cet effet il proposa d'apporter à une société constituée au capital d'un million, dix mille mètres de terrain en échange d'actions libérées, dont la valeur eut été égale à celle du prix de revient du terrain apporté. Malgré la situation morale et financière du promoteur de l'entreprise et l'appui moral qui lui fut donné, le public resta indifférent à ses démarches.

Une autre tentative faite par les industriels de Saint-Denis eut un peu plus de succès, mais elle repose plus sur la philanthropie que sur la spéculation, c'est pourquoi nous en reparlerons un peu plus loin.

Action de la Philanthropie.—La philanthropie a servi de base à des opérations immobilières relatives aux petits logements, soit à des sociétés, soit à des particuliers.

La plus ancienne société créée à Paris dans ce but a été la Société des Habitations Ouvrières de Passy-Auteuil. Grâce aux hommes dévoués qui la dirigent—parmi lesquels nous citerons M. le Sénateur Dietz-Monin, M. le Député Siegfried, et M. Cheysson—elle a obtenu de beaux résultats qui éviteront bien des démarches à des sociétés analogues. Ainsi la Société de Passy est arrivée à ne payer que 30 francs par tuyau de chute horizontal, qui dessert une quinzaine de privés, tandis qu'un particulier serait obligé de verser à la caisse municipale une somme quinze fois supérieure, soit 450 francs. Espérons que ce précédent déterminera l'administration des égouts à modifier la taxe relative à l'écoulement des vidanges à l'égout.

La Société de Passy-Auteuil a émis des actions hypothécaires qui rapportent 4 pour cent l'an ; comme ces obligations sont garanties par des propriétés qui ont une valeur double de celle des titres émis, elle a mis à la disposition des travailleurs des placements plus avantageux que ceux de la Caisse d'Épargne.

L'association philanthropique, grâce au zèle de M. Georges Picat, qui a entrepris une véritable croisade pour propager les habitations ouvrières convenables, affecta, il y a trois ans, le produit d'une donation de 600,000 francs faite par M. Heine, à la construction de maisons à petits logements. La première de ces maisons située rue Jeanne d'Arc est divisée en logements de deux pièces, la deuxième établie boulevard de Grenelle contient des logements de trois pièces. La société reconnut que les logements de trois pièces revenaient à un prix trop élevé et qu'il fallait habituer progressivement la population parisienne aux avantages d'une habitation spacieuse, c'est pourquoi elle divisa un troisième bâtiment qu'elle construisit avenue de Saint-Mandé, en logements contenant au plus deux pièces et un cabinet assez vaste pour pouvoir y coucher un enfant.

Les maisons de l'association philanthropique sont louées de façon à faire rapporter 5·6 pour cent brut au capital engagé, 1·6 pour cent, soit 28 pour cent du revenu brut, sont affectés aux charges. Cette proportion est un peu trop faible pour tenir compte des charges d'une maison occupée par des ouvriers, car la pratique a démontré que jusqu'ici le revenu net obtenu a été de 3·80 pour cent. La société pourra donc, dans un temps fort peu éloigné, suivre l'exemple donné par la fondation Peabody en Angleterre, et construire de nouveaux immeubles.

On reproche aux maisons de l'association philanthropique de contenir des pièces qui n'ont qu'une seule fenêtre exposée à l'air extérieur et des privés qui ont un accès direct dans des chambres où il est possible de placer des lits. Nous regrettons que l'habile architecte des maisons de l'association philanthropique ne se soit pas mis à l'abri des critiques que des étrangers pourraient faire à sa distribution en se basant sur la législation sanitaire qui est plus stricte dans leur pays que dans le nôtre. Ainsi, en Angleterre, il est interdit de construire des maisons dites *back-to-back*, c'est-à-dire des habitations qui ont une seule façade exposée à l'air extérieur ; et en Allemagne on ne tolère pas que des privés donnent directement dans une chambre

destinée à l'habitation. Il faut dire que les privés des maisons de l'association philanthropique sont établis suivant le système du tout à l'égout et qu'ils sont soumis après chaque opération à un lavage énergique produit à l'aide d'un appareil fournissant dix litres d'eau à cet effet.

Jusqu'à présent, la pratique n'a révélé aucun inconvénient sérieux relatif à la distribution adoptée par M. Chabral, et grâce aux avantages qu'il a su mettre à la disposition des habitants des maisons dont nous parlons, chaque fois qu'un locataire donne congé dix autres se présentent pour le remplacer.

Nous ajouterons que d'une part la solidité des constructions et d'autre part leur revenu certain ont décidé la Compagnie des chemins de fer d'Orléans à prêter sur hypothèque, au taux de 3 pour cent l'an, tout l'argent nécessaire à une société fondée au capital de 30,000 francs, pour faire établir par M. Chabral des maisons analogues à celles qu'il a fait exécuter pour le compte de la société philanthropique.

Une société d'un genre particulier, la Société française des habitations à bon marché, présidée par M. Siegfried, a déjà rendu, quoique de fondation récente, de grands services en cherchant à provoquer la formation de sociétés de construction d'habitations à bon marché. Grâce à des conférences faites par MM. Siegfried, G. Picat, Rochard, plusieurs sociétés analogues à celles qui fonctionnent avec tant de succès à Mulhouse, à Rouen, au Havre, à Lyon, ont été créées à Belfort, au Havre, à Oullins et à Saint-Denis. La fondation de cette dernière société est due à un concours organisé par la Société française des habitations à bon marché. Ce concours avait pour bu de lotir un terrain d'une surface de 10,000 mètres et de le couvrir de petits logements, 48 concurrents répondirent à l'appel de la société. Les projets exposés à l'Hôtel de Ville furent examinés par M. le Président de la République et par un grand nombre de notabilités.

Des prix d'une valeur de 3,000 francs furent distribués à la suite du concours, mais aucun des concurrents n'ayant rempli les vues du comité d'organisation de la Société des habitations économiques de Saint-Denis, je fus chargé par lui de m'occuper de la question. J'ai commencé par faire une enquête sur les petits logements de Saint-Denis, et je reconnus que si d'une part ils étaient dans un état déplorable, d'autre part il y en avait près des 1,200 qui étaient vacants. Je pus d'autre part m'assurer que la mortalité dans les quartiers ouvriers variait entre 30 et 40 pour cent, c'est pourquoi je conclus de mes recherches qu'il était plutôt nécessaire de construire des maisons modèles que d'établir un grand nombre de logements. Le comité d'organisation adopta mes vues et il se contenta de constituer la société au capital de 300,000 francs, divisé en actions de 500 francs dont le revenu a été limité au taux maximum de 4 pour cent.

Une création originale est due à la Société coopérative du XVIII^e^ arrondissement. Cette société rencontrant des difficultés pour se loger convenablement acheta un terrain et construisit une maison à l'aide d'un prêt. Grâce aux bénéfices réalisés sur ses opérations la société sera bientôt libérée. Les étages de la maison de la société sont divisés

en petits logements qui présentent une disposition remarquable. Le fourneau de cuisine est adossé à la paroi de la salle à manger, percée de façon que de cette pièce on puisse voir le feu de foyer qui sert à cuire les aliments. L'ouverture est encadrée du côté de la salle à manger par un chambranle de cheminée. En été on ferme l'ouverture à l'aide d'un registre de fonte.

Un grand nombre de particuliers ont contribué à l'amélioration des petits logements parisiens, soit par leurs écrits, soit par leurs travaux pratiques. Citons parmi les écrivains les plus remarquables, MM. Jules Simon, G. Picat, Émile Muller, A. Raffalovich, Anetole Langlois, Cheysson, Antony Roulliet.

Pour mon compte j'ai essayé de propager le plus possible les principes qui doivent guider un bon constructeur en publiant avec M. Émile Muller l'ouvrage intitulé les Habitations Ouvrières en tous pays,* dont à l'occasion de l'Exposition Universelle de 1889 nous avons publié une deuxième édition. J'ai publié seul l'Économiste Pratique et l'État des Habitations Ouvrières à la fin du XIX^e^ siècle, pour rendre compte des travaux pratiques que j'ai faits dans le but de démontrer la possibilité d'introduire, en France, les *Building Societies* qui ont rendu tout de services en Angleterre et en Amérique. A cet effet j'ai construit une centaine de maisons suivant une vingtaine de types différents moyennant des prix qui ont varié de 3,400 à 10,000 francs.

J'ai donné les plans d'exécution de mes types dans mes ouvrages, et je suis persuadé que si une société faisait en grand ce que j'ai réalisé en petit, elle obtiendrait des avantages bien plus sérieux que moi et qu'elle arriverait facilement à rendre beaucoup de locataires propriétaires, soit d'une maison, soit d'une somme d'argent, par le seul fait de payer régulièrement leur loyer pendant un certain temps.

The Insanitary Conditions of Workrooms, Bakehouses, etc., in Paris.

BY

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This paper recounts what has been done in Paris by a sub-committee, charged by the Commission on Insanitary Dwellings to prepare a Bill, to be presented to the Chambers, to deal with the work-rooms and kitchens of pastrycooks. With M. André Gély, of the Paris Municipal Council, the writer and three other experts gathered a large body of evidence bearing upon the complaints of the insanitary condition of many of these establishments, presented by Messrs. Hudelo and

* État des Habitations Ouvrières en tous pays, par Muller et Cacheux. État des Habitations Ouvrières à la fin du XIX^e^ siècle. L'Économiste Pratique, par É. Cacheux, Baudry et Cie, 15 rue des Saints-Pères, Paris.

Napias. The causes of unhealthiness found were so much alike in the different cases, and so general, as to justify the sub-committee in regarding them as vices inherent, so to speak, to the business. They were chiefly want of light and air; dangerous position of the ovens and furnaces; open gutters passing through the workshops; want of water, and consequent uncleanliness generally; proximity to the workshops of water-closets and urinals, and the presence, even in the rooms themselves, of portable apparatus for the same purpose, such as open barrels; and, above all, the miserable and dangerous sleeping arrangements for apprentices and workmen. Many employés were compelled to sleep either in the workrooms themselves or in places better described as holes or cellars than as chambers. The fatalities recently occurring in the Rue Gay-Lussac, and in other parts of Paris (they were euphemistically called accidents), were only too easily accounted for by the facts observed by the committee. The furnaces, generally fed by charcoal and deprived of flues, were often placed in cellars in communication with living and sleeping rooms. The gutters in some cases ran with a mixture of soap-suds and rain-water; the floors, of broken tiles, harboured grease, fat, and more repulsive deposits in other cases; and in most the walls and floors were incrusted with fermenting accumulations of humidity, grease, and sugar, which gave out a sickening smell. In some laboratories were found receptacles for the household slops, unsealed, with no siphon or trap, communicating directly with the sewers, and admitting sewer gas unimpeded into the workrooms. All these causes were fruitful in rendering these workshops sources of infection,—attacking not only the workmen, but not infrequently the employer himself, and the members of his family,—and sources of corruption for the alimentary products turned out of the workshops. The worst danger of all arose from the practice which prevailed of making the apprentices sleep in the work-rooms. In the Rue Gay-Lussac, in April last, three workmen or apprentices were suffocated by the fumes of the furnace by the side of which they slept. A few days later, of four pastrycooks' workmen and apprentices sleeping in a cellar, unventilated and unlighted, three were suffocated, and the employer himself, who slept above in the back shop on the ground floor, was nearly overcome by the carbonic acid fumes emanating from a furnace in the basement. In this basement the four unfortunate employés (three apprentices and one adult) slept two by two in beds placed in a hole opposite that containing the oven, both being scooped out of the earth under a passage to which access was given by an open gateway. The writer regards the "Bakehouses Regulation Act of 1863," as a piece of severe English legislation which France ought to follow in the main; on that Act was founded a Bill which the sub-committee proposed for adoption in Paris. The principal provisions of this Bill were that the laboratories and kitchens of such establish-ments should not be less than 9 ft. 4 in. high, should be lighted from the street or a wide court, and should be freely ventilated by air; waste water not to pass across the floor except in hermetically sealed pipes, properly trapped; every furnace to have a hood, conducting the smoke into a chimney not less than 12 in. by 10 in. in section, and extending

to the top of the house; and, wherever possible, a second tube of the same dimensions should be placed at the end opposite to the chimney. All sinks and openings for waste water to be trapped; there should always be a sufficient supply of water for drinking purposes; and no urinal, water-closet, or apparatus of like nature should be tolerated in any laboratory, kitchen, or bakehouse. All drain-pipes should be on the principle of "all to the sewer"; proper closets and urinals should be provided outside the workshop, all supplied with sufficient and proper apparatus, and trapped. Sleeping in places devoted to work, or in proximity to ovens, or in any underground room whatever, should be absolutely forbidden. Finally, the author calls attention to the desirability of limiting the number of persons sleeping in a room in proportion to its cubic contents, and to the immorality likely to result from apprentices and adults sleeping together indiscriminately.

Common Lodging Houses.

BY

P. Gordon Smith, F.R.I.B.A.

In approaching the subject of common lodging-houses it is necessary to come to a clear understanding as to what constitutes a common lodging-house; for outside the circle of officers and members of local governing bodies, there appears to be but an indistinct notion of what a common lodging-house really is. Not infrequently it is erroneously mixed up with that kind of model lodging-house which is now often advocated and provided as dwelling accommodation for the poorer classes of the labourer and artizan community in our cities and towns. Nor must the common lodging-house be confused with either the Seamen's Lodging House dealt with under the Merchant Shipping (Fishing Boats) Act, 1883 (Section 48), or with the night refuges provided by certain philanthropic individuals and societies. The application of the term common lodging-house has given rise to many questions, legal and otherwise, as to what houses ought to be classed as such, and be registered accordingly, and I feel sure that many of our friends, especially our foreign visitors, will need some explanation upon the point, the more so as common lodging-houses form the subject of several special legislative enactments.

In the absence of any complete statutory interpretation of the term, I will first explain that a common lodging-house is, in a certain limited sense, a sort of inn or hotel resorted to by certain of the very poor for temporary residential purposes, in which sleeping accommodation is provided in common, in one or several rooms, at a charge of 4*d.* or 6*d.* per night, and where those who resort to it cater for themselves as regards food, and ordinarily use one kitchen in common.

On several occasions efforts have been made to define with precision what constitutes a common lodging-house. It has been held that evidence that hawkers, itinerant picture-frame makers, chair-makers, musicians, bone-gatherers, and persons suspected of begging resorted to a house for lodgings and had their meals in the kitchen at the same table, paying 6*d.* per night each, is sufficient to establish that the house is a common lodging-house requiring to be registered under the Public Health Act, 1875. It will thus be seen that the question as to what is a common lodging-house depends, not so much upon the precise definition of the term as the consideration whether the circumstances of its occupation are such as involve supervision by the sanitary authority in order that its general cleanliness, ventilation, good ordering, &c., may be secured.

Common lodging-houses had existed in Great Britain for many years prior to legislative enactments for controlling them. In the "Report of the Poor Law Commissioners," 1842, the late Edwin Chadwick gave descriptive statements showing the horrible condition—sanitarily and socially—of the common lodging-houses in all parts of the kingdom, and showed how prolific they were in the propagation of disease and vice. But it was not until 1851 that Lord Ashley—better known later on as the philanthropic Earl of Shaftesbury—induced the Legislature to pass the Common Lodging Houses Act, an Act the preamble of which states that "it would tend "greatly to the comfort and welfare of many of Her Majesty's poorer "subjects if provision were made for the well-ordering of common "lodging-houses." That Act, however, and a subsequent one passed in 1853, were, so far as they related to common-lodging houses in the provinces, repealed by the Public Health Act, 1875; and, while the control and supervision of the common lodging-houses within the Metropolitan district (exclusive of the City) was allowed to remain in the hands of the police as enacted under the original Acts, that of the common lodging-houses throughout the rest of England and Wales was entrusted to the local sanitary authorities existing or constituted under that Public Health Act. As regards the City of London, the Common Lodging Houses Act of 1851 specially exempted the City from the operation of that Act, but the Commissioners of Sewers, acting as the Sanitary Authority for the City under the Sanitary Act, 1866, control houses let in lodgings, and have a code of regulations very similar in their general requirements to the bye-laws as to common lodging-houses in force in other sanitary districts.

That the subject of common lodging-houses is one of some importance as affecting directly and indirectly the whole community, will be better understood from the fact that, according to the evidence given in 1884 before the Royal Commission on the Housing of the Working Classes, as many as from 20,000 to 30,000 persons resort to them in London alone for lodgings every night, and some of the houses are certified to hold upwards of 500 lodgers. According to the Report of the Commissioners of Metropolitan Police for 1889 there were 988 common lodging-houses on the Register, making up, in the aggregate, accommodation for 33,964 persons.

From information kindly furnished to me by the officers of certain provincial towns, I am able to show the extent to which the system of common lodging-houses prevails in each of the towns named.

Name of Town.	No. of Common Lodging Houses on Register.	Aggregate No. of Beds in Common Lodging Houses on Register.	Largest number of Beds in any one Common Lodging House on Register.		
			For Men.*	For Women.*	For Married Couples.*
Birmingham	86	1,861	186	13	12
Liverpool	878	9,895	172	66	230
Manchester	234	6,556	649	53	60
Salford	58	1,419	148	10	5
Bristol	51	1,006	106	6	8
Leicester	27	601	107	21	6
Nottingham	50	762	50	21	10
Leeds	88	2,714	555	0	43
Newcastle-upon-Tyne.	96	1,053	30	12	10
Hull	53	1,353	90	8	16
Bradford	52	930	128	19	13
Sheffield	40	1,273	85	20	14
Brighton	18	292	30		4
Portsmouth	17	303	49	8	4

* In some instances the arrangements admit of the beds in these columns being interchangeable.

It will be well, perhaps, to briefly specify the accommodation that ought to be found in a complete common lodging-house. This should comprise an adequate day room for each sex, fitted with a fireplace and range suitable for the cooking of the lodgers' food, also a sufficient scullery or wash-house. Likewise dormitories for each sex, furnished with single bedsteads, bedding, &c. Lavatories, separate from the dormitories, are also necessary; and suitable and sufficient closet accommodation. In addition to the separate dormitory accommodation for each sex, cubicles or separate rooms may be provided for married couples, for, be it remembered, that any man and woman applying for such accommodation—and the Act of Parliament imposes no duty on the keeper of a common lodging-house in regard to the family relationship of the lodgers—may be received as such in a common lodging-house. In some few common lodging-houses a separate reading room has been provided, but this is comparatively exceptional. In several I have noticed that lockers are provided, in which those lodgers who may be regarded as regular customers can, for a trifling extra fee per week, leave their property with a certain amount of safety.

A few instances have come under my notice in which buildings have been specially erected as common lodging-houses, but these are comparatively rare. More frequently the common lodging-house is a capacious dwelling house which has ceased to serve its original purpose, owing to entire change in the character of the neighbourhood, and which has

been altered and adapted to serve its new purpose; but more often it is a warehouse or factory that has been altered and adapted to the purpose. These latter are generally the best kind of building for the purpose, as they usually have large rooms capable of fair light and ventilation. Some buildings of this sort now provide accommodation for 200 to 300 lodgers, and consequently involve a considerable amount of capital, and of attention and management on the part of the proprietor.

I propose to state briefly some of the chief conditions under which common lodging-houses are allowed to be carried on, and then to refer to a few of the more important of those conditions, with the object of ascertaining how far those conditions can be regarded as adequate and satisfactory.

The statutory laws require the controlling authority in every district to keep a register of the common lodging-houses within their districts, with the names and addresses of the keepers, and the number of lodgers which each house is authorised to receive. The keeper of every such house is required to have it registered, and the controlling authority are not to register any such house until they have had it inspected and approved for the purpose by some officer in their employ; they may further require, as a condition of registration, that the keeper shall produce a certificate of character; also that he shall exhibit the words "Registered Common Lodging House" in a conspicuous place outside the house. He may further be required to comply with sundry other enactments as to water supply, periodical lime washing of walls and ceilings, reporting any occurrence of infectious disease amongst the lodgers, the admission of the duly appointed officer to inspect the house, &c. In the provinces, moreover, every sanitary authority is required to make byelaws* for the following objects, such byelaws being confirmed by the Local Government Board in London before they can be put into operation:—For fixing and from time to time varying the number of lodgers who may be received into a common lodging-house, and for the separation of the sexes therein; for promoting cleanliness and ventilation in such houses; for the giving of notices and the taking precautions in the case of any infectious disease; and generally for the well ordering of such houses.

In the Metropolitan District corresponding regulations are issued by the Commissioners of Police, and the regulations now have to be confirmed by the Local Government Board.

It will be obvious that one of the chief features in the foregoing enactments which calls for careful attention, is that which requires the controlling authority to cause every common lodging-house to be inspected by some responsible officer in their employ, before placing it on the Register and certifying it as fit for a certain number of lodgers. For the guidance of sanitary authorities and their officers, the Local Government Board have issued a memorandum, of what should be looked for on the occasion of such inspection. In that memorandum it is pointed

* The model byelaws of the Local Government Board. Annotated edition. Knight & Co., London, 1890.

out that the house should possess the conditions of wholesomeness needed for dwelling houses in general; and that it should further have arrangements fitting it for its special purpose of receiving a given number of lodgers. The details as to general wholesomeness are set out, and the method of determining the accommodation is then given. The numbers for which the house and each sleeping room may be registered will depend, partly upon the dimensions of the rooms and their facilities for ventilation and partly upon the amount of accommodation of other kinds. In rooms of ordinary construction to be used for sleeping, where there are the usual means of ventilation by windows and chimneys, about 300 cubic feet will be a proper standard of space to secure to each person; but in many rooms it will be right to appoint a larger space, and this can only be determined on inspection of the particular room. The house should possess kitchen and day-room accommodation apart from its bedrooms, and the sufficiency of this will have to be attended to. Rooms that are partially underground may not be improper for day rooms, but should not be registered for use as bedrooms. The amount of water supply, closet or privy accommodation, and the provision of refuse receptacles should be proportionate to the numbers for which the house is to be registered. If the water is not supplied from works with constant service, a quantity should be secured for daily use on a scale, per registered inmate, of not less than 10 gallons a day where there are waterclosets, or five gallons a day where there are dry closets. For every 20 registered lodgers a separate closet or privy should be required. The washing accommodation should, wherever practicable, be in a special place and not be in the bedrooms; and the basins for personal washing should be fixed and have water taps and discharge pipes connected with them.

Time precludes us from considering all these particulars in detail, but there appear to me to be one or two important points that deserve special attention. There is, for instance, the question of fixing the number of lodgers to be received into each particular common lodging-house; and there is the question of the separation of the sexes, and the provision for married couples.

As regards the methods by which the accommodation of a common lodging-house is fixed, this should depend not only upon the numbers which the dormitories may be calculated to hold, but upon the provision of adequate day-room space for the lodgers. In fixing the accommodation of the dormitories, it is usual to reckon not less than 300 cubic to each adult lodger. Although this minimum amount is a very small one, it has been arrived at by a careful regard partly for health considerations and partly in view of the difficulties of lodgment in the metropolis and other populous places. This standard, however, should under no circumstances be diminished; it is only where there are at least the usual means of through ventilation by proper windows and chimney flues that so small an allowance is permissible; but where there are only indifferent means of ventilation, or where the room is of unusual height, or where the room is used by day as well as by night, a larger amount of space per lodger ought ordinarily to be required. In

the case of children under 10 years of age, it is usual to reckon two such children as one person. Children, however, are not by any means numerous in common lodging-houses.

Much as I should like to see a larger minimum standard of space allowed to each lodger, I am not prepared to suggest that the amounts above referred to should be increased, since the difficulties of securing larger amounts would, I believe, be practically insurmountable; but I do think that the utmost care should be exercised to insure that where only those small amounts of space are afforded, all available means of ventilation are not only provided but are made use of; and it is in this respect that the usefulness of constant inspection will be most evident. At the same time it must continually be borne in mind that the ordinary *habitué* of a common lodging-house is an individual who cares nothing whatever for ventilation or fresh air, provided he is warm; that he is often under-fed, and but poorly clad; and that in wet weather his clothing is rarely dry. Under such conditions it is not surprising if he selects the lodging-house where the dormitory is (to him) the most comfortable and free from cold draughts and fresh air. The keeper, too, has the interest of his customers at heart, and he gladly sees the street-hawker, organ-grinder, pedlar, and other customer come night after night to his establishment; in fact, like every good hotel-keeper, he strives to make his customers comfortable according to their individual ideas of comfort; otherwise, if he has a large establishment, he may find, perhaps, a hundred of his beds empty, and this would inflict on him a loss of some 10*l.* or more a week; and, however important we may consider the ample supply of fresh air in the dormitories of these lodging-houses, we have to take care not to apply the rules as to ventilation with undue rigour, or in a manner that would indeed drive away those whose comfort it is our desire to increase.

The question of warmth is, of course, closely associated with ventilation, and if the lodging-house keeper invariably had a reserve of bed clothing and blankets that could be resorted to in cold weather, there might possibly be rather less difficulty with regard to ventilation. But while the reserve of blankets is rarely large (and there is no great encouragement to be very profuse in their supply, since the losses by theft, both in regard to sheets and blankets, are considerable, for they get torn up for use as underclothing or to serve as bandages for wounds, &c.), the difficulty of getting fresh air into the dormitories, unless it were first warmed, will always be great, since there is scarcely any ventilator that will escape obstruction unless it be wholly invisible and inaccessible. In the day time the windows of the dormitories have to be kept fully open for a specified time morning and afternoon, but means for the constant ventilation of the dormitories when occupied at night are indispensable, and the less visible they are the better. Compared with the amount of space per lodger prescribed by the police regulations of Paris and Berlin, our own 300 cubic feet is decidedly small. In Paris the lodging-houses under systematic supervision are required by the police to have in each occupied room a minimum height of $2\frac{1}{2}$ metres, and each lodger 14 cubic metres of air space, which is equal to some 480 cubic feet. In Berlin the police

regulations applicable to lodging-houses under their inspection require a minimum amount of 3 square metres of floor space and 10 cubic metres of air space, equal to about 350 cubic feet for each lodger, this latter being reduced to one half in the case of children under 6 years of age, and to two-thirds for children between 6 and 14 years old.

The separation of the sexes in common lodging-houses is a further point which, apart from its moral aspect, is not without an important bearing on the general question of hygiene. It is a matter dealt with by byelaws in the provinces and by police regulations in the metropolis. In the byelaws it is usual, except as regards husband and wife, to prohibit any person of the male sex above 10 years of age from using or occupying a room used or occupied as a sleeping apartment by persons of the female sex, and similarly to prohibit any person of the female sex from using or occupying a room used or occupied as a sleeping apartment by persons of the male sex above 10 years of age. These rules do not interfere with the children of tender years remaining with their parents at night. How far it is desirable to separate the sexes elsewhere than in the common dormitories may be open to question, but as a matter of fact it is practically never done, except in those common lodging-houses which are intended for one sex only. In the others; men and women associate freely in the common rooms, where clothes are mended and often washed and dried, unlimited cooking goes on, and meals are taken. I assume that the Legislature intended the separation of the sexes to be applicable only as regards the common dormitories, otherwise specific arrangements would be made, as they easily might be, for the same separation in the day rooms. The separation of the sexes does not, of course, apply to married couples, since man and wife could no more be lawfully separated in a common lodging-house, where they pay for their accommodation, than in an ordinary inn or hotel, provided the accommodation afforded be such as will conform to ordinary rules of decency, and is duly certified by the responsible authority. That this accommodation may be, and frequently is, improperly used, will not, I think, be denied, but this point is beyond the scope of the present paper.

Cottage Homes for the Industrial Classes.

BY

ROWLAND PLUMBE, F.R.I.B.A., F.S.I.

In common with many experts who have given great attention to the subject, I hold strongly the opinion that every effort should be made to prevent any further concentration of industrial homes in the already overcrowded streets of the central districts of the metropolis. These residences should be scattered widely, and should be situated as far as practicable from the already congested central districts, and the working classes should be induced to spend their hours of rest and recreation in the purer and more abundant light and air of the suburbs. Especially

is this desirable in the case of the wives and children, even though quarters may be found in the best built and most advantageously situated flats in the many blocks of model dwellings that have been provided so largely of late. This opinion is strongly confirmed by the view taken in an article contained in the recently published volumes of Mr. Charles Booth's valuable work on the "Labour and Life of the People." It is written by Miss Octavia Hill, under the heading "Blocks of Model Dwellings," Vol. 2, Sec. 2, Fol. 262, "Influence on Character." The article is much too long to quote on the present occasion, but is strongly in favour of separate cottage homes, while the many objections to block dwellings are forcibly demonstrated.

In building new districts, social and class prejudices have hitherto prevented the richer and more cultured classes of the population from living in close proximity to those whom they consider below them in social standing. This prejudice is probably as strong also on the part of the poorer population, and so each class prefers to keep to itself. These tendencies are unfortunate, and in the present state of society, seemingly insurmountable. The great difference in the value of land and property in fashionable and in poorer neighbourhoods also prevents proximity of the classes; still, in providing estates for the industrial population, an attempt should be made to get as great a mixture and variety in the social scale of the inhabitants as is practicable.

Therefore in providing model villages for the artizan and industrial class, I think that provision should be made, and attractions should be laid out, for all sorts and conditions of inhabitants likely to reside in them. The site should be a salubrious one, all natural defects of soil and climate should be overcome as far as possible. The locality should be easy of access to large industrial centres, with cheap and frequent means of transit by road and rail. It should be laid out with wide and well-made roads and footways, which should be planted with suitable trees, and made as attractive as possible. The drainage and sanitary arrangements should, of course, be perfect; each home should be self-contained, and should be bright, cheerful, well arranged, commodious, and healthy; the houses well set back from the public footway, with gardens in front and a good drying ground in the rear, which could also be laid out as an additional garden or recreation ground, and where under proper regulations domestic animals and poultry might be kept.

The houses should be varied in plan and accommodation to suit the habits of all classes, and of the different sized families likely to occupy them. They should, of course, be substantially built, and every sanitary requirement should be provided. They should be decorated and finished in a pleasing manner to suit the best taste of the occupants, and a general air of comfort, brightness, cleanliness, and cheerfulness should be given to them, as also to the estate generally. Open spaces for recreation and for garden allotments should be provided. Pressure should be brought to bear upon the local authorities so that the provisions of the Education Act, the Baths and Wash Houses Act, the Public Libraries Act, and all other beneficial legislation of a like character may be carried out, and suitable buildings for the same should be provided. Churches, parish rooms, public board schools, polytechnic institutes, coffee taverns, and

clubs of all kinds should also be provided; a sufficient provision of shops should likewise be built in suitable positions; and the question of public-house accommodation should also be most carefully considered, and (if provided) not placed in positions likely to create discomfort and disorder.

The classes of people inhabiting such estates should pay weekly rents, and habits of thrift should be encouraged by always insisting that the rents should be paid at least one week in advance. The inhabitants should also be encouraged to invest even small amounts in the capital of the company, so that they may co-operate in its undertakings. Houses should not be sold to individuals, as in that case abuses at once spring up, but the whole estate should be owned and managed by one company, the tenants being shareholders wherever possible. The inhabitants should be encouraged to take an interest in the maintenance of the company's property, and forms should be provided on which should be stated any want of repair or other matter requiring attention, these should be left at the estate office, and a staff should be appointed to attend to the same. The company should maintain and manage a proper staff of officials and workmen to attend to all matters of repair and maintenance. It should be established on a proper business footing, and financially it should be so managed as to pay a remunerative rate of interest to its investors. However philanthropic the motives of the promoters may be, there should be no sense of favour to the inhabitants, who should be encouraged to feel that they are paying a fair rental for the accommodation provided. The company should aim at paying a dividend on each estate of 5 per cent.; but it is highly probable that as such property extends and the security increases in value, the public would be found willing to invest in it at a considerably lower rate.

Now the foregoing very incomplete and sketchy description of a model cottage village may seem to many overdrawn, if not altogether chimerical. In order to prove that this is not so, I propose to give a short account of the latest village of the kind that has been actually erected under my design and superintendence. This estate, having an area of 100 acres, is called Noel Park, and is situate at Wood Green, a suburb in the N.E. district, about 10 minutes' walk from the Hornsey and Wood Green Stations of the Great Northern Railway. Green Lanes and Noel Park Station on the Great Eastern Railway is actually on the estate, and steam tramways run along the main road on which it is situate.* The estate has a very gentle slope towards Tottenham; the soil is the usual dense clay found in the outlying parts of London on the north side of the river, which is always much improved by roadmaking, planting, paving, and draining.

The main avenue is 60 feet wide; other avenues are 50 feet wide, and the cross streets 40 feet wide. As the houses are built the roads are completely made up, channelled, and curbed, and the footways are entirely paved with York stone, and planted at regular intervals (mostly with plane trees). At present it is contemplated to provide a large open space as a recreation ground.

* A general plan of the estate, as proposed to be completed, was exhibited by the author.

The general drainage of the estate, in accordance with the requirements of the local authorities, has been arranged on the dual system, the rain and surface water being kept separate from the sewage. No drains run through the houses, back drains with intercepting manholes, specially ventilated, being provided for all terraces. The system of ventilation of sewers has specially been considered, the usual ventilating openings in the roads are arranged to act simply as inlet ventilators, the sewers having manholes at short distances apart, with specially designed valves and upcast ventilation shafts carried above the houses. Automatic flushing tanks are also provided.

In laying out the estate, care has been taken that all houses are set well back from the road, all having front gardens. The objectionable practice of bringing the corner houses out to the pavement line of the return roads is in all cases avoided, the corner houses of the terraces being set back, and specially designed and planned so as to form an architectural adornment to the terrace of which they form a part. There will be about 2,500 houses and shops built on this estate, mostly of five different classes. About 1,305 houses are already built, and are nearly all occupied.

The first class houses are built on plots having a frontage of about 16 feet wide and 85 feet deep, with a floor area of about 1,065 feet on both floors, containing eight rooms, including the scullery. Each house is provided with two sitting-rooms, kitchen, wash-house, and four bedrooms, also a back entrance, with coal cellar, larder, washing-copper, and water-closet, and in most cases an additional water-closet on the chamber floor. The houses are let at a rental of from 11*s.* to 11*s.* 6*d.* per week, including all rates and taxes, which are paid by the company. The greater number of these houses are provided with a water-closet on the first floor; and in such cases the back rooms are fitted up as kitchens and sculleries complete, so that they may accommodate two families if required.

The second class houses are built on plots having a frontage of about 15 feet 6 inches by a depth of 80 feet. The floor area is 936 feet, containing seven rooms, there being only three bedrooms on the first floor. The other accommodation is similar to that last described, except that there is no upstairs water-closet. The weekly rental of these houses is about 10*s.* per week.

The third class houses are built on plots having a frontage of 15 feet by a depth of about 70 feet, and possess a floor area of about 800 feet, containing six rooms, three being bedrooms. The weekly rental of these houses is about 9*s.* per week.

The fourth class houses are built on plots having frontages of about 14 feet 6 inches by a depth of about 70 feet, with a floor area of 660 feet, containing five rooms, there being two bedrooms on the first floor. The rental of these houses is about 7*s.* 6*d.* per week.

The fifth class houses are built on plots having a frontage of 13 feet by a depth of 60 feet. The floor area is about 470 feet, containing a front living room, with kitchen and small wash-house behind, with two bedrooms over. The rental of these houses is about 6*s.* per week.

In addition to the various classes of houses just described, an endeavour has been made to provide for still further varied requirements by adapting them as flats, two stories high, for two families. In the case of third class houses the staircase is shut-off, the upper floor being arranged as a separate dwelling, consisting of a living room and two bedrooms, with an outside staircase down to the back garden, the closet and wash-house being held in common. These are let at 4*s.* 6*d.* per week the lower flat, and 5*s.* per week the upper flat. Advantage is taken of the corner houses to get separate entrances at the side. Second class houses also are similarly arranged. Each flat has its own scullery, wash-house, and w.c. The rental of these houses is 5*s.* a week for each floor, and 6*s.* to 7*s.* a week for houses with special accommodation. First-class houses have been arranged in the same way. The frontages are extended from 16 feet to 19 feet, and entirely separate entrances and outside doors are given to each flat, a small additional bedroom being obtained on the first floor. The rental of these houses is 7*s.* a week ground-floor, and 8*s.* a week for first-floor flats. The corner houses have an extra floor, and are let at special rates, viz., 10*s.* 6*d.* for the first and second floors. It is proposed that by far the largest number of houses built should be of the smaller class, in order to encourage the industrial classes in the effort to avail themselves of houses at a rental which will not make it necessary to take in lodgers.

In the general planning of these houses the company does not profess to carry out any specially new arrangement; the type, with the exception of the fifth-class houses and double flats, being that which seems to have been universally adopted in all town and suburban terrace-dwellings, as giving the greatest accommodation at the cheapest rate; where however, any special requirement has to be met, as (for instance) in the case of shallow, corner and other irregularly shaped plots, the architect has availed himself of the opportunity to design plans of almost every variety of arrangement; but for the general terrace plans the Board has not found it practicable to adopt a more convenient and economical plan than that shown.

In the general view of the terraces of the first and second-class houses, a feature in the design is made of the corner houses; and with a view of breaking up the monotony of the long lines which terraces in streets produce, specially designed features are introduced at intervals so as to break up and improve the sky-line of the buildings; advantage is also taken of these features to improve the accommodation of the houses, so that a return may be obtained for the extra outlay by an increased rent, which is readily obtained in such cases.

The houses are all built with a layer of concrete over the whole area of the buildings; the walls are of brickwork, the party walls being hollow or 14″ thick, to prevent the passage of sound between the tenements; slate and cement damp-proof courses are used; the walls are faced with red and yellow bricks, with terra cotta or artificial stone cills and flower guards; the roofs are mostly slated, but to give variety many are tiled; the whole being built with the best materials and designed to have a bright and cheerful appearance. The space under the ground floor is specially ventilated, as are also all the rooms, Tobin

tubes and deep inner beads to windows being provided to each room. There is a constant water supply, and no cisterns are used except the water waste preventors to the water-closets. The sanitary arrangements are of approved yet simple character, all waste and other pipes being discharged over open trapped yard gullies. No soil or rain water drains run through the houses, as the pipes are carried along the back gardens and are provided with ventilated manholes for inspection and flushing at suitable distances. There are also similar manholes at the junction of these drains with the pipe sewers in roads.

The general requirements of the inhabitants have been studied. Already the estate has been formed into a separate parish, and a church has been built holding 850 on the ground floor, with mission hall, parish rooms, and all the usual church societies. Building sites have been offered for churches of other denominations; a fine board school has also been built; various social clubs already exist, as also cricket, foot-ball, and other clubs; space is reserved for a public hall, should it ever be required, and every facility will also be given for the erection of polytechnics and other buildings for technical education; also for free libraries, swimming baths, and other similar buildings, whenever the authorities are ready to put the various Acts of Parliament providing these buildings into operation. On the other estates, halls for the use of the inhabitants have been built, but they are so little used, that there is but little encouragement to repeat the experiment. In certain parts shops have been built, also stables, and space is reserved for workshops and laundries.

Although it is not thought advisable to interfere directly with the conduct of the various societies that have sprung up, yet the managers of the estate are always desirous of helping them forward when once started by the tenants. With this object prizes are given, and other facilities granted in aid of the same. Some of the land not yet built upon is used for cricket and recreation grounds, and also for allotment gardens, and it is hoped to reserve permanently enough land for this purpose. In order to promote thrift and self-respect, the estate is managed on the lines first indicated in the first part of this paper, and no public-houses or pawnbrokers shops are allowed on the estate.

The estate is occupied by young married people, a few retired tradesmen with moderate incomes, travellers, warehousemen and clerks, railway employées, tradesmen's assistants of all kinds, artizans of all classes, cabmen, letter carriers, labourers, policemen, pensioners, &c. The inhabitants are healthy, and but few complaints are made. The death-rate on the company's estates from January to the end of June 1891 was about 14·41 per 1,000, as compared with a death-rate in the general district of about 15·25 per 1,000.

In respect to co-operation by the tenants in the development of the company, but little can, at present, be said. Every opportunity is given to them to invest; only a few shares are, however, held by them.

It is believed that this estate would have been by this time completed had proper railway facilities been provided. There are cheap workmen's trains from the Great Eastern Station on the estate, and

from the stations on the Great Northern Railway, not far distant, but these early morning trains by no means cover the necessities of the industrial population. It is a fact not generally known that, except on the Midland Railway, the third-class passenger, who is packed closely in his carriage, and allowed to travel but once, backwards and forwards, on six days of the week, actually pays, on an average, about as much for his railway fares as a first-class passenger who, having a season ticket can travel as often as he likes in comfort, and has also the right to travel on Sundays.

That there is nothing impracticable in the granting of third-class season tickets, is shown by the example of the Midland Railway. This line, as is well known, has no second-class, but its first and third-class passengers are treated with perfect equality with regard to season tickets. What is urgently needed is cheap workmen's trains throughout the day, and failing this, the issue of third-class season tickets, at cheap rates, in proportion to the other classes.

In regard to general statistics, it may be interesting to know that an average of about 25 houses per acre are built upon the estate, including space for roads, and that the population is at the rate of about seven people per house, so that when it is completed it will contain a population of about 17,500. There will then be over five miles of roads and streets formed. The outlay including the land, up to the present time has been about 460,000*l.*, and the net income is now about 21,000*l.*, so that the estate (though only about half developed) already pays over 4½ per cent. The estate is one of four held by the Artizans, Labourers', and General Dwellings' Company (which holds other properties), whose assets are over 2,000,000*l.* sterling. The company has for years paid a dividend of 5 per cent. to its original shareholders, and the shares are now issued at a premium of about 10 per cent. to pay 4⅓ per cent. dividend. The market price of the stock is above this.

I trust I have now demonstrated the possibility of providing for our industrial classes bright, cheerful, well arranged, commodious, healthy and self-contained cottage homes under the best sanitary conditions, at a cost which will adequately remunerate the promoters of such good work.

Block Dwellings for the Industrial Classes.

BY

JOHN F. J. SYKES, B.Sc., M.B., Medical Officer of Health for St. Pancras.

Of all the classes into which the people may be divided, those that give rise to the most difficult sanitary, social, and economic problems are, proceeding from below upwards, the pauper, the residuum, and the working classes. The housing of the pauper is undertaken by the State; the distinguished efforts of Miss Octavia Hill and other philanthropists are directed towards ameliorating the dwellings and habits

of the residuum, the most difficult class to deal with from the variability of type and condition; whilst public companies and private individuals are engaged in constructing improved dwellings to house the working classes and gather them out from herding in tenement houses among the residuum.

In order to keep within reasonable bounds it is necessary to limit working-class dwellings to unfurnished dwellings consisting of from one to three, or, possibly, four rooms, generally let on weekly tenancy, at rentals of from 2*s.* or 2*s.* 6*d.* to 7*s.* 6*d.*, or perhaps even to 10*s.* This will include tenement, cottage, and block dwellings.

Dwellings in "made down" or "tenement" houses, houses originally constructed for occupation by one family, but let out in separate tenements to two or more families, have for years engaged the efforts of sanitarians for their improvement by adaptation, or their displacement by demolition.

The type of the true cottage-dwelling is the cottage with or without upper floor, self-contained, and occupied by only one family, although it is not difficult to apply this term too narrowly. These dwellings still exist in large numbers in the metropolis, but their construction and surroundings are the very antithesis of suburban cottage-dwellings, and they may in most cases be added to the category of desirable demolitions.

Block dwellings, on the other hand, are understood to comprise sets of dwellings super-imposed one above the other on the same base, possessing a common stair, and differing only from residential flats in length of tenancy, rental, and accommodation. Under the present inadequate restrictions as to construction, not a few recently constructed dwellings of this type are nearly as unsatisfactory as the dwellings they have displaced. But the majority are well-built, and it only requires the framing of bye-laws, and their due enforcement in the construction of this class of buildings, to ensure that in future all shall be constructed with due regard to health. This is a subject which urgently needs the attention of the legislature.

In Mr. Charles Booth's recently published work on Labour and Life of the People, Vol. II., London, the existing block dwellings of the metropolis have been classed in various categories, of which the following is a summary:—

Light, Air, and Sanitation.	Blocks.	Tenements.	Population.
"Very bad" and "bad" - -	115	6,859	37,911
"Fair," "good," and "very good" -	360	28,921	151,197
TOTAL - -	475	35,780	189,108

To provide for increase of population, cottage-dwellings on new estates in the suburbs or the country, coupled with cheap and expeditious transit, are most desirable.

But in order to promote the health and comfort of town dwellings, the demolition of permanently insanitary and overcrowded dwellings and of houses falling into dilapidation and decay is necessary, and it is then a question of utilising the site. If the site is to be devoted to other purposes, then provision for a number of persons equal to the population displaced may be made by the erection of cottage-dwellings in the suburbs, for instance, in demolitions made for railway purposes. If, on the other hand, new and improved dwellings are to be erected upon the site, these may be either cottage or block dwellings.

The effect of clearing small areas appears to be, firstly, to displace all grades of occupants alike, and to re-distribute them in the surrounding neighbourhoods, and, secondly, when the new and improved dwellings have been erected, to set up a reverse current by which the better grades are drawn into the new buildings, leaving the indifferent and inferior in occupation of the older buildings on the areas surrounding the site cleared; whether the new buildings be urban or suburban the same process of re-allocation takes place.

It cannot be doubted that the air and the surroundings of the suburb are more beneficial to the health, especially of growing children, than those of the town; but the disadvantages of distance make themselves appreciably felt in the expenditure of time, energy, and money on travelling, the relaxation of family ties, and the curtailment of home life, the husband and other members of the family taking meals away from home, the frequent loss of work if the exigencies of occupation require the worker to be at short call, the long absence in occupations entailing exceptionally early or late hours, the increased expenditure in the family marketing, the extra cost, &c., if other members of the family besides the husband work away from home, and other disadvantages.

The success of suburban villages shows that these disadvantages may be overcome, and that the conditions may be made to fit the occupations of certain classes; but, on the other hand, the evidence of representative working men before the Select Committee of the House of Commons inquiring into artizans' and labourers' dwellings went to show that to many classes of workmen the disadvantages of distance were insuperable, and these classes must be housed upon the cleared sites, whether cleared by public undertaking or by private enterprise.

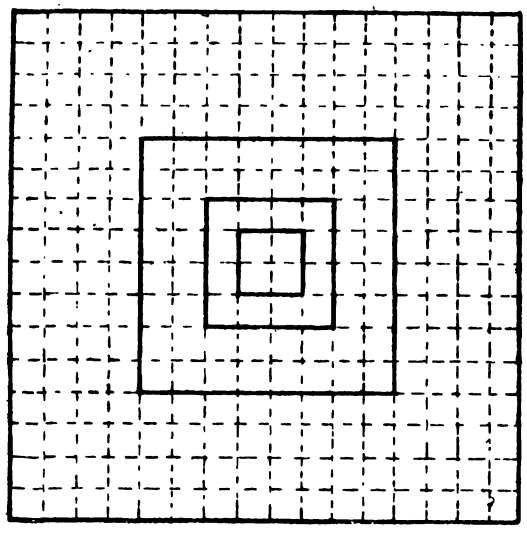
It then becomes a question whether small or large buildings should be erected upon the site. To erect cottage-dwellings in the centre of cities would be costly, and would place the rental beyond the reach of the classes for whom they are intended. Besides, the overcrowded condition would be reproduced in housing the same number of persons on the same area, or a large proportion must remain unprovided for.

The object to be aimed at is to diminish the crowding by expanding the population through a greater amount of cubic space with increased light and air; and, whilst reconstructing, to provide improved sanitary arrangements, and to so dispose the dwellings as to enable them to be effectually supervised and protected.

The first consideration, therefore, is the amount of cubic space *enclosable* on square space.

The square space required for a cube to stand upon so that it may be surrounded by a square open area equal in width to half its height, (assuming that contiguous cubes would provide the other half, so as to complete a width of surrounding area equal to the whole height) would be twice the length of the base or side of the cube squared, $(2\ S)^2$: whilst the capacity of the cube would be the length of the side cubed, $(S)^3$.

A



Length of Side (S).	Cubic Capacity $(S)^3$.	Square Space required $(2\ S)^2$.
10 feet.	1,000 cubic feet.	400 square feet.
20 „	8,000 „	1,600 „
30 „	27,000 „	3,600 „
40 „	64,000 „	6,400 „
50 „	125,000 „	10,000 „
60 „	216,000 „	14,400 „
70 „	343,000 „	19,600 „

So that a cube containing 64,000 cubic feet would require only 16 times instead of 64 times the area of square space required by a cube containing 1,000 cubic feet,—a simple and striking illustration of the gain of cubic space upon square space by increase in size under similar conditions. The effect upon the construction of buildings, although following parallel lines, is not such a simple deduction; but upon the same area and under the same conditions a much larger proportion of cubic space to square space may be enclosed by increasing the size of building, and the dwelling space may be further increased by the economy of staircase space and terrace construction in erecting rows of blocks.

In order to estimate the comparative amount of cubic space enclosable in actual building it is desirable to briefly consider the height, depth, length, and spacing of blocks.

The height of rooms must be proportionate to size for the purpose of lighting and ventilation. Windows materially influence the height; it is undesirable to have windows that cannot conveniently be seen through or be easily manipulated. A window six feet high is ample, and if the bottom rail be not more than $3\frac{1}{2}$ feet from the floor, and the top nearly reach the ceiling, as it should do, we have a height of over $9\frac{1}{2}$ feet. Even half underground rooms are restricted to a height of 7 feet, a very minimum. Sir Douglas Galton considers it desirable in small rooms to obtain a height of 10 feet to facilitate ventilation. Increase of height beyond what is necessary and desirable increases the number of stairs required to reach the next floor and diminishes the number of storeys, or renders it necessary to increase the elevation, in either case increasing the proportionate cost. So that about 10 feet may be assumed as a good standard for moderate sized dwelling rooms. Whatever the height adopted, it is not desirable that the rooms in the upper storeys of a block should be of less height than those of the lower.

The number of storeys is obviously governed by the height of the rooms and the total height of the building.

The total height of blocks is limited by many considerations. It is highly desirable, almost necessary, that a street should run between every alternate row of blocks. Although in the metropolis in old streets, houses can be and are being constantly raised to heights out of all proportion to the intervening space, no new street can be formed of less width than 40 feet, and no new building which shall exceed in height the width of the street can be erected on the side of a street less than 50 feet wide. Last year only, a clause was introduced into a General Powers Act of the County Council limiting the total height of buildings to 90 feet. So that, provided it does not exceed 90 feet, the height of buildings is under no legislative control, except in new streets between 40 and 50 feet wide. With increased height, difficulty of access to the topmost storeys increases, and the rentals tend to diminish. There is additional cost for increased strength of construction, and the gain in cubic space in proportion to square space tends to diminish. Beyond a certain height lifts would be required, the construction and working of which would add to the cost, and endanger the lives of the large infant population prevalent in these buildings. There is a height beyond which it is on all counts false economy to build. So that blocks would be limited to a height of from 40 to 60 feet, or to four or six storeys of 10 feet; practically the latter is about the present maximum limit.

The depth of a room according to Trélat should not exceed one-and-a-half times the height from the floor to the top of the window. This would give an incidence of 30° to the rays of light reaching that portion of the floor furthest from the window; if an angle of 45° were required the depth would equal the height. According to the latter, a room 10 feet high would be 10 feet, and to the former 15 feet deep as a maximum. The depth of ordinary double fronted terrace houses may be roughly taken as varying from 25 to 35 feet, and by doubling the maximum assumed depth of a single room, as above, a depth of 30 feet *is reached.*

There is no advantage in constructing rooms for the working class families of a width or length in the line of frontage requiring more than one window to adequately light them, and it is highly desirable that they should not exceed a length that can be adequately lighted at the sides. The incidence of light entering horizontally impinges on the lateral walls at an angle of 45°, the dark angles on each side of the window diminishing or increasing as the side walls approach or recede, and the width of the room must be governed more by the width and situation of the window than by the height or depth of the room.

Block dwellings encourage increased length as well as depth of rooms on account of the greater economy of ground space obtained in many storeyed as contrasted with single-storeyed buildings. Firstly, because the initial ground space occupied by the increased area of the building serves a number of storeys, whereas in single-storeyed buildings increased area of the building requires a correspondingly increased amount of ground to be covered for each separate building. Secondly, because the greater the area of building served by a single staircase, the greater the economy of staircase space. So that the length of a single block is limited by the number of consecutive rooms accessible from the same staircase.

The healthiest condition of construction is that in which through ventilation, or perflation, may be obtained. Blocks may be so constructed as more or less to reproduce one of the bad features of back to back houses. Corridors and lateral passages are undesirable, and it is also undesirable that bedrooms should become passage ways to rooms beyond; these considerations limit the number of consecutive dwelling-rooms on either side of the staircase.

The length of a row of blocks is limited by the length of the ground area, but it is also desirable that the blocks should not be more numerous than the superintendent can efficiently supervise and protect.

It is unnecessary to enter here into the disadvantages and unhealthiness of single-fronted dwellings, especially when erected in terraces, from the absence of rear space and of through ventilation or interior perflation. This is exhibited in its worst form in back to back houses, when two rows of single-fronted dwellings are erected with their fronts facing in opposite directions, the same back party-wall serving both rows, and a public street running along each front. Given the principle that the fronts of all buildings should face open spaces proportionate to the height of the buildings and along their whole length, and that the rear space should not only remain open, but should not be converted into a public thoroughfare (a most important point), there is no economy of ground space in constructing single-fronted buildings, whether they are back-to-back or not.

Out-buildings, towers, or projections abutting at right-angles to the line of frontage are objectionable by impeding light and air on either side, in proportion to the distance they advance from the main front, and according to orientation. On the other hand, there is great advantage in being able to obtain cross-ventilation and cross-light between the main building and the projection when this contains the sanitary

arrangements. Where such projections are constructed an additional amount of open space should be required in proportion to the projection, and the projection should not be allowed to advance so as to obstruct exterior perflation, and on no account so far as to close up the stretch of open space, whether in front or at the rear, forming a cul-de-sac in either case, the one of the courtyard and the other of the street, nor should terraces be permitted to abut directly upon one another at right angles. Orientation also will necessarily affect the lighting, the least obstruction to the sun's rays being presented by buildings running north and south.

Terraces of blocks being double-fronted, both rear and front should face open spaces proportionate in width to the height of the buildings. The question whether this proportion should be equal to the height, according to Dr. Clement; or to one-and-a-half times the height, according to Dr. Trélat; or should vary with latitude and orientation, according to Adolphe Vogt; or with city zones according to Von Gruber; was discussed at the Vienna Congress, and remains undecided. But that the width of open space on both frontages should be proportionate to the height of the dwellings is accepted, and anything less than a width equal to the height of the building above ground level would be unacceptable to hygienists.

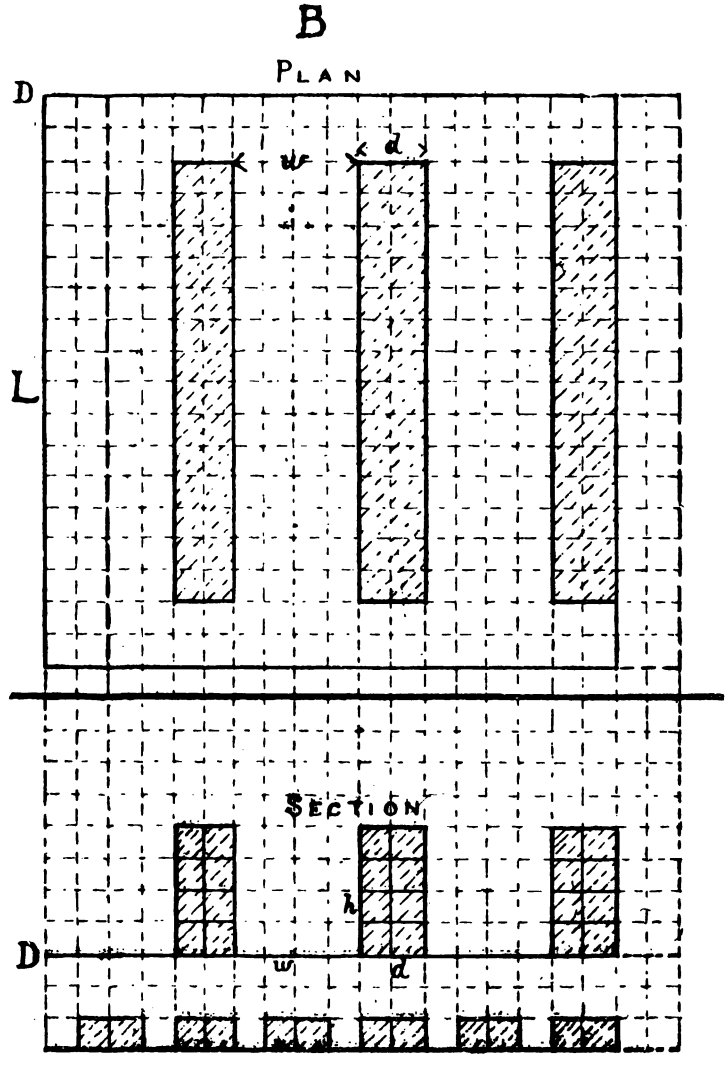
The reckless manner in which at the present moment blocks of dwellings are being erected, with an utter disregard for this provision of light and air, calls most urgently for legislative restrictions in the construction of this class of buildings.

Present metropolitan legislation, so far as front space is concerned, only affects buildings in new streets, and new streets are few and far between in London; furthermore, it does not affect streets over 50 feet wide. So far as rear space is concerned, it only provides for a space 10 feet wide extending the length of rear fronts of buildings from 15 to 30 feet wide, 450 square feet being held to suffice for any length over 30 feet, but even this inadequate provision is inoperative when the site has previously been occupied in whole or in part by buildings; and, furthermore, when it does become operative it permits the whole of the open space to be built over up to the level of the first floor.

The growing antipathy of philanthropists to block dwellings is greatly justified by the dread of the ultimate effects of the total absence of any restrictions as to this class of buildings erected on old sites. The crusade against insanitary dwellings, without adequate restrictions upon the buildings that will replace them, may make the last state worse than the first. The attitude of antipathy must become one of sympathy, and the efforts of sanitarians and philanthropists should rather be directed to righting the wrong as soon as possible.

Having briefly considered the conditions of construction, we may now proceed to calculate the relative amount of cubic space enclosable on a rectangular area under varying conditions of height of building. Such a calculation would only apply to a small area, at the most limited to a few acres, for in a larger area other factors would be introduced which are beyond present consideration.

When superimposing dwellings one above the other, for every additional floor or storey the floor area of the storey is economised, and it is only necessary to provide space equal to the areas of the two fronts. One interspace will serve the opposed fronts of two blocks, that is, each block will have on either side of it one-half the amount of open space due to it, and the width of open space to be calculated with each block will be proportionate to the height and number of the storeys; the same applies to the ends of the rows of blocks. Therefore, the depth of the block, plus the width of the open space on one side, will equal the depth of total space occupied by one block, and this divided into the total depth of the area will give the number of blocks. Assuming that the length of the blocks is equal to the length of the area, less the space required at each end, and that each storey or stage is of the same height, then the cubic capacity of one block multiplied by the number of blocks will give the total cubic space enclosable.



Let it be assumed that the total area is 500 feet by 250 (about 2·87 acres) the former being the depth, the latter the length coinciding with the long axis of the buildings; that the depth of each block is 30 feet, allowing two rooms each of 15 feet deep; that the height of each floor is 10 feet; and that the width of intermediate space is equal to the height of the blocks.

(1.) The first step is to find the number of rows of blocks.

Let D = total depth of area;
d = depth of one block;
h = height of one storey;
n = number of storeys;
w = width of one interspace;

then w = h and $\frac{D}{d + nh}$ = number of blocks.

If 1 storey high - $\frac{D}{d + h} = \frac{500}{30 + 10} = 12{\cdot}500$ rows of blocks.
„ 2 storeys „ - $\frac{D}{d + 2h} = \frac{500}{30 + 20} = 10{\cdot}000$ „
„ 3 „ „ - $\frac{D}{d + 3h} = \frac{500}{30 + 30} = 8{\cdot}333$ „
„ 4 „ „ - $\frac{D}{d + 4h} = \frac{500}{30 + 40} = 7{\cdot}142$ „
„ 5 „ „ - $\frac{D}{d + 5h} = \frac{500}{30 + 50} = 6{\cdot}250$ „
„ 6 „ „ - $\frac{D}{d + 6h} = \frac{500}{30 + 60} = 5{\cdot}555$ „
„ 7 „ „ - $\frac{D}{d + 7h} = \frac{500}{30 + 70} = 5{\cdot}000$ „

(2.) The second step is to find the cubic capacity of one row of blocks.

Let d = depth of one block;
h = height of one storey;
n = number of storeys;
L = length of area;

then d × nh × (L−nh) = cubic capacity of one row of blocks.

	cub. ft.
If 1 storey high - d × h × (L − h) = 30 × 10 × (250 − 10) =	72,000
„ 2 storeys „ - d × 2h × (L − 2h) = 30 × 20 × (250 − 20) =	138,000
„ 3 „ „ - d × 3h × (L − 3h) = 30 × 30 × (250 − 30) =	198,000
„ 4 „ „ - d × 4h × (L − 4h) = 30 × 40 × (250 − 40) =	252,000
„ 5 „ „ - d × 5h × (L − 5h) = 30 × 50 × (250 − 50) =	300,000
„ 6 „ „ - d × 6h × (L − 6h) = 30 × 60 × (250 − 60) =	342,000
„ 7 „ „ - d × 7h × (L − 7h) = 30 × 70 × (250 − 70) =	378,000

(3.) The third step is to find the total cubic space enclosable.

Let N = number of rows of blocks;
C = cubic capacity of one row of blocks;

then N × C = total cubic space enclosable on the area.

If 1 storey high	-	12·500 ×	72,000 =	900,000 cubic feet.
„ 2 storeys „	-	10·000 ×	138,000 =	1,380,000 „
„ 3 „ „	-	8·333 ×	198,000 =	1,650,000 „
„ 4 „ „	-	7·142 ×	252,000 =	1,800,000 „
„ 5 „ „	-	6·250 ×	300,000 =	1,875,000 „
„ 6 „ „	-	5·555 ×	342,000 =	1,900,000 „
„ 7 „ „	-	5·000 ×	378,000 =	1,890,000 „

On this area 500 feet by 250 feet, equal to 2·8787 acres, the amount of cubic space enclosable per acre, would be—

1 storey high	-	312,641 cubic feet.	
2 storeys „	-	479,383 „ -	53·3
3 „ „	-	573,175 „ -	19·5
4 „ „	-	625,282 „ -	9·1 } Increase per cent.
5 „ „	-	651,335 „ -	4·1
6 „ „	-	660,020 „ -	1·3
7 „ „	-	656,546 „ -	0·5

On the above area buildings four storeys high would enclose double the amount of cubic space of buildings one storey high under the same conditions.

On a larger area the increase of cubic space would be proportionately greater. For instance, if the area were double the depth and length (11·4784 acres), then under the same conditions the following would approximately be the amount of cubic space enclosable per acre :—

1 storey high	-	320,220	
2 storeys high	-	501,950 =	56·7
3 „	-	614,300 =	22·3
4 „	-	687,000 =	11·8
5 „	-	736,000 =	7·1 } Increase per cent.
6 „	-	766,650 =	4·1
7 „	-	786,800 =	2·6
8 „	-	798,450 =	1·4
9 „	-	803,800 =	0·6

So that, given an area, the greatest amount of cubic space enclosable with due regard to health provisions may be calculated, and the cubic space adopted as a uniform standard more valuable than the mere number of tenements, or of rooms, or the square space, as a basis of calculation for the size of block buildings, cost, accommodation, density, and mortality. And in proportion to the cubic space enclosable the number of persons housable on an area may be calculated.

Restriction of time will only allow of a brief but sufficient reply to the prevalent objections to blocks.

It has been urged that block dwellings are, from their unsightliness, repellent to the classes sought to be attracted; but it is a poor compliment to the resources of architects to attribute to them inability to provide embellishment at moderate cost by beauty of form, colour, and ornament. The objection that the working classes avoid them on account of their collective arrangement, and the objection that a class superior to those they are intended for takes possession of them, as well as the fact that residential flats are in favour may be left to the objectors

to reconcile with the construction of the dwellings and the habits of occupants.

It has been anticipated that blocks may rapidly deteriorate; but when substantially constructed, with due regard to sanitary and social requirements, their condition will depend upon efficient supervision and maintenance. Under proper management the one roof, drain, staircase, water-supply, gas service, &c., upon which so many are dependent is less likely to remain defective or unremedied than when under less direct supervision, and with fewer to complain, as in smaller buildings. Only improper usage can cause deterioration, and this applies equally to the small as to the large building.

The staircase open to the street is rightly regarded as a most objectionable feature. The staircases of tenement houses whose front doors are rarely closed are largely accountable for the defilement and destruction in this class of houses, and the same deterioration will ultimately doubtless take place in the blocks which replace them. It is necessary to distinguish between being open for the purpose of light and air, and being open to the access of any and everybody who chooses to enter. The former is as highly beneficial as the latter is detrimental. The staircases should open into the intervening space between the rows of blocks, but there should be only one public or main entrance to the courtyard or garden of block dwellings, and this should be directly under the control of the superintendent. The legislature is largely responsible for these open staircases, by the unreasonable manner in which the inhabited house duty is assessed, which compels the staircase to be open and form part of the street in order to claim exemption for the dwellings under 20*l.* a year (7*s.* $8\frac{3}{10}$*d.* per week) rental. This is a condition that urgently requires alteration.*

Apart from the influences of town life, is there any reason to suppose that block dwellings are *per se* unhealthy? Residential flats are not held to be less healthy than self-contained houses. Provided that the proportion of open to covered space is adequate to permit of proper access of sunshine and daylight, of sufficient aëration and perflation, increased height of building can scarcely cause any direct injury to health. On the other hand, the conditions of life are dissimilar in cottages and in blocks in important respects.

In block dwellings the families, and especially the children, are brought into closer and more frequent contact, and the sanitary arrangements are under more constant supervision. The effects of these conditions upon the mortality, as compared with London generally, have been most ably demonstrated in a paper upon the vital statistics of block dwellings read before the Royal Statistical Society in February of this year by Dr. Newsholme. He showed that, notwithstanding that the age-distribution of population in Peabody buildings was much less favourable to a low mortality than in London as a whole, the death rate was 2 per 1,000 lower, and that the birth-rate was much higher,

* The Customs and Inland Revenue Act, 1891, which has only just become law, indirectly removes the obstruction hitherto existing to the construction of block dwellings with one main entrance under the superintendent's control.

and the infantile mortality much lower than in all London. But that the death-rate of children between one and five years of age was higher, and was caused by scarlet fever, diphtheria, and still more largely by whooping cough and measles, diseases to which children are so prone, and which are communicated mainly by direct infection. In this respect the social condition induced by block dwellings resembles schools, and is equally remediable. Another point elucidated was the influence exerted by the greater supervision of sanitary arrangements, in the fact that the death-rate from typhoid or enteric fever was one-half that for all London, and it is well recognised that this disease is the best test of sanitary conditions available.

Time, again, will not permit of the consideration of the various classes of block dwellings, but the distinction between dwellings with private sanitary and domestic conveniences and those with conveniences in common is important, as it materially affects the social conditions, as well as the cost, and also the cubic dwelling-space available. The higher aim should be to construct blocks of "homes," the expression so aptly used by Mr. James Moore, the well-known secretary of the Improved Industrial Dwellings Company. This may be supplemented by baths and wash-houses supplied with hot and cold water and hot drying closets, a mortuary, means of isolation for minor infectious ailments, possibly a reading and a recreation room, or any addition that may make the workman's quarters in towns desirable residences according to the rental he can afford; and efficient regulations must be trusted to complete the work.

The high price of land impels private individuals and companies to erect block dwellings in great cities; but there is a limit to the size of these blocks, especially in height, as I have shown; with each storey of the building raised the economy of space increases in a correspondingly diminished proportion, so that the ratio of height of building to width of interspace being fixed, economy will self-impose a limit to the size of block dwellings.

The conditions of construction requisite to secure adequate light, air, space, and sanitation, in order to prevent injury to health may be defined. The maximum amount of cubic space encloseable on a given area in accordance with these conditions may be calculated. In proportion to the cubic space enclosable, the maximum population housable on a given area may also be calculated. But in the construction of block dwellings, the requisite conditions should not be permitted to be infringed, and to insure that these conditions will be observed, their construction should be controlled by special legislative enactment, imperial or local.

The reasons for demanding special legislation are various. All buildings, whether inhabited or not, are controlled by special legislation, but the requirements, and particularly those for open space, are totally inadequate for dwelling-houses of large size. Large blocks of dwellings, such as workhouses, prisons, asylums, barracks, &c., are erected under the responsible supervision of governmental or public authorities, which ensures due provision with regard to health being made; but no special

control is exercised to prevent irresponsible individuals from erecting a class of block dwellings inferior to the dwellings they displace. By special permissive enactment, the Government has provided in the Public Health Acts Amendment Act, 1890, that a building not originally constructed for dwelling purposes shall not be occupied as a dwelling unless it satisfy the requirements of the surveyor, but there is no definition of what these requirements are or should be. Factories are controlled by special legislation. Special legislation, again, has been created for the exemption of block dwellings from inhabited house duty, and upon medical officers of health the onus has been thrown of certifying that these buildings are constructed with proper provision for health, but there are no definitions of the conditions that entitle to this exemption. The Housing of the Working Classes Act, 1890, deals with houses unfit for human habitation, but there is a wide margin between the absolute unfitness of existing structures and the requirements necessary for future erections.

In order, therefore, to enable the special legislation already created in regard to existing block dwellings to be complied with, and also to prevent such dwellings from being erected in future in a manner prejudicial to the public health, special legislation to control the construction of block dwellings for the industrial classes in cities is indispensable.

Two and Three-Storeyed Tenements for the People.

BY

LOCKE WORTHINGTON, A.R.I.B.A.

The following remarks and figures are an effort to assist in showing the desirability and to prove the commercial possibility of constructing in our crowded centres of population isolated model homes for the weekly-wage-earning classes, in buildings of two and never more than three storeys in height, in accordance with certain arrangements of planning.

Although it may be well that philanthropy should be the motive in all schemes for the housing of the people in the metropolis or other centres of population, their execution should be based on a sound commercial foundation, and the rental of the buildings such as to secure a reasonable dividend. True philanthropy dictates the desirability of low tenement houses, and I have worked out two schemes to prove their commercial possibility.

The various commercial companies and other agencies which are employed in the metropolis in improving the dwellings of the weekly-wage-earning class have almost invariably erected blocks of tenements three, four, five, six, and even seven storeys in height, so arranged as to

crowd the greatest accommodation on the site, with often but little consideration for proper light and air, and constructed so as to save expense by the provision of common entrances, staircases, and conveniences. Many of these model blocks in London are excellently planned and built, while some are so arranged and constructed as to be no better than the condemned houses they replace.

It is not the province of this paper to enter into the merits and drawbacks of these existing metropolitan model blocks, which are being laid before the section by other members.

It would be well for the community if the 30 metropolitan agencies were to work more in the spirit of the following suggestions, which have already been tried, though not to any great extent, in the metropolis:—(1.) To buy up and put in order the existing dilapidated cottage tenements to be found in almost all localities of the metropolis. (2.) To construct in the suburbs, off the regular line of street traffic, two-storeyed houses at a rental within the reach of the classes earning low weekly wages. (3.) To erect in the metropolis new model tenements, never more than three storeys high, and, in so far as possible, private isolated homes.

With regard to No. 1, viz., the improvement of existing small houses:—If well carried out and superintended, Miss Octavia Hill's plan of purchasing houses, purifying them, and fitting them for habitation, is excellent and beneficial in all ways. With rentals varying from 2*s.* to 10*s.*, the cost of accommodation per family has been 118*l.* to 130*l.*, and the undertaking pays an average of 4 to 5 per cent. On the other hand, the cost of accommodation for families in such model blocks as are to be found in Farringdon Street, for instance, varies from 171*l.* to 315*l.*

With regard to No. 2, viz., the construction of suburban dwellings:—There is an estate in South Bermondsey which provides the following luxurious and private homes for 6*s.* 6*d.* The houses are built for two families, each tenant being responsible only for his own tenement, which consists of a parlour, bedroom, kitchen with the best kind of kitchener, and scullery with fireplaces, copper, sink, &c. With the exception that one tenement is above and the other on the ground floor there is no difference between upstairs and downstairs, and the homes on the first floor are so planned that the upstairs occupiers can, if they wish, keep themselves entirely private. On a similar principle, but with less luxury, suburban houses should and could be built at a rental of 3*s.* to 4*s.* 6*d.* Such homes are undoubtedly the most popular if the workman can arrange to live in the locality.

In support of No. 3, viz., the construction of cottage homes in the town, let me say that the existing model blocks often do not let well in localities where small houses enter into competition, even where the dilapidated condition of such houses may be both injurious and uncomfortable. Tenants prefer an uncomfortable cottage to a tenement in a large block of dwellings.

I have taken some pains to interview the superintendents and tenants of many model blocks in the metropolitan area, and also the

tenants in many of the dilapidated houses of our side streets, and almost invariably they state that they have a deeply-rooted dislike to living on the same staircase as 20 other families, who may or may not be respectable, and consider moving into "the buildings" as only a step better than going into "the house."

Estimate proving the commercial possibility of isolated houses in parts of the metropolis being buildings constructed only two stories in height.

CAPITAL ACCOUNT.

	£	s.	d.
Contractor's tender for building 200 cottage homes complete, according to drawings, specifications, and quantities -	29,000	0	0
Add for unforeseen extras and fees -	2,500	0	0
Total building capital required -	£31,500	0	0

ANNUAL EXPENDITURE.

Annual rental of land at 2½*d.* per sup. foot per annum - - - - -	646	10	0
Maintenance, on precedent of properties in the neighbourhood of Whitechapel, including rates, taxes, repairs, collection, management, empties, arrears of rent, &c. - - - - - -	951	0	0
Sinking fund - - - -	40	0	0
Total maximum annual expenditure	£1,637	10	0
Total income from rents - -	2,795	0	0
Total expenditure - - -	1,637	10	0
	£1,157	10	0

This return of nearly 4 per cent. would become a safe 4½ to 5 per cent. if the tenements were three instead of two storeys high. The rents average 2*s.* 6*d.* a room, the majority being two-room tenements. The homes are isolated, and the accommodation is liberal.

The above figures are based on competitive tenders procured from contractors in the spring of 1890 on definite sites, in order to verify the statements made in the author's pamphlet "The Housing of the "Poor in London," April 1890, which was a plea for 'Cottage Homes 'in the Metropolis.'

DISCUSSION.

Mr. E. Bond, M.A., Hampstead, speaking on the question of flat roofs, said that people would not use them. They were difficult to keep dry, and expensive in plumbing. Architects had put up a number of buildings with flat roofs, but somehow they did not take. With regard to the cottage-dwellings advocated by Mr. Rowland Plumbe, he was glad to hear so pleasing an account of the experiment at Noel Park, but he regretted the mention made of Miss Octavia Hill, because the latter did not go so far as Mr. Plumbe, although that lady had undoubtedly a *penchant* for cottage-dwellings. He knew a lady who had lived for a considerable period in a block of dwellings, and who spoke of them very highly. He was of opinion that when such dwellings were properly looked after, the objections commonly brought against them would be found to have no good foundation, but the lady admitted that the system would break down if anybody who chose to pay the rents demanded were admitted. A proper superintendent and proper regulations were necessary, and the regulations must be enforced strictly, as in city residences they always were. He was not an advocate for surrounding London with groups of houses such as Noel Park. London might be considered a huge wheel, of which the lines of communication were the spokes. Noel Park was on one of the great lines of communication, and if such groups continued to be multiplied they would soon have crowded agglomerations in certain spots with great open spaces intervening. London was made up of a number of once separated villages, now in process of time connected. The cottage-dwelling, which had usually one story above the ground-floor, was the commonest type of London house, and if, as had been stated, there were only 200,000 persons dwelling in the blocks, they were not likely just yet to oust the cottage-dwellers. With regard to block dwellings, he did not think there was much in the noise or in the height objection. A more formidable objection was the want of proper spacing. If the sites were of sufficient area for the number of blocks to be erected, the ground-floors ought to be as light as the upper floors. There was an enormous difference in the price of sites in different parts of the metropolis. He knew of sites where the price of the land would reduce the ground-rent per room to 3*d.*, 3¾*d.*, or 4*d.*, while other quite similar sites, bought in the ordinary market, would cost 7*d.* per room.

Mr. Noble Smith, F.R.C.S. Edin., said that the last speaker declared that the flat roof had been tried as an experiment, and had failed. That might be only because it had not been sufficiently tried. They could not hope to influence much the formed habits of the adult; it was the young whose habits they might be able to reform. A most prolific cause of disease and death among children was due to rickets. It had always been found that as opportunities of getting exercise in fresh air increased, the tendency to rickets diminished, and that disease alone was the cause of so large a proportion of all ailments that it was worth a great effort to reduce it. Nine-tenths of the cases of accidents treated in hospitals were accidents occurring in the streets—children run over or knocked down by vehicles. The effluvium of the streets was injurious, and rendered them very undesirable places for recreation.

Mr. Ralph Nevill, F.S.A., pointed out that much of the unhealthiness of back streets had passed away through the introduction of asphalte. All back streets and courts should be asphalted. The whole life of people living in courts had been changed by asphalte. Concrete

might be successfully employed for flat roofs, but nothing was so likely to be permanent as asphalte. The principal objection he had to urge against flat roofs was that there was no society there. The cottages that surrounded our village greens in England were among the great beauties of English landscape. Block dwellings were not attractive to country people, and such people would not go on roofs. With regard to spacing, he agreed with Dr. Sykes, and pointed out how the latter's arguments might be strengthened.

Mr. J. P. Seddon, F.R.I.B.A., said that London was no place for factories, and some day when we had stifled an archbishop, we should find that out. London would be greatly improved if through the squares, which at present seemed to be given up to cats, they were to drive wide boulevards.

Mr. S. M. Burroughs pointed out that in New York City the upper floors were more sought after, and obtained higher rents, than the first and ground floors. A higher value was placed upon the flats the higher you went up. The houses were higher, and had a larger number of floors than those known to our builders. The high price of land was the cause. It was the public that had given the high value to the land, and yet the public were not allowed to have any share in the profits. On the contrary, it had to pay more and more as the increment grew, to persons who had not earned it.

Mr. Hooper (Director of the Victoria Dwellings Company) referred to the paper on "Block Dwellings," and to the objections commonly urged against them. One of the best-founded objections was the great height of the buildings. They caused draughts of cold air in the streets below, and shut off from them the rays of the sun. It would be an improvement to increase the size of the windows. He had had some experience of the use of flat roofs as playgrounds. It was not of a favourable character. The tenants at the top were inconvenienced by the noise, and gave notice to quit. The Company had been obliged to forbid the use of the roofs for playgrounds. It was very difficult to keep such roofs watertight. The erection of blocks of dwellings, in places till then occupied by small houses, had often been found beneficial to a district. One such district, which had always been a terror to the police, on being cleared and the site occupied by blocks of dwellings, had been rendered quiet and tranquil.

Mr. H. L. Beckwith (Liverpool) wished to mention some of his Liverpool experiences of blocks of dwellings in the Scotland-road district. Large numbers of people of the lower class had been cleared out of small old houses and sent into blocks, but it was found that they would never buy coals as long as the doors and windows were intact. If Dr. Sykes could suggest a remedy for that, they would be greatly obliged to him.

Mr. Councillor Hannam (Leeds) agreed that it was very difficult to make flat roofs watertight, and he regarded them as things of the past. With regard to small houses, he said they had in Leeds a large number of back-to-back houses. They admitted that such houses were bad in principle. They could forbid them, but to do so would be as useless as to forbid the putting up of walls anywhere round about Leeds. The Council must pass the plans sent in, if they fulfilled certain conditions. They had 50 blocks of dwellings, each of eight buildings in a block. He was glad to welcome the remark that the width of the street should be in proportion to the height of the houses.

Mr. H. H. Collins said he did not wish it to go forth that the section approved of building back-to-back houses, which stood condemned by the whole world. As to block dwellings, a great objection to their use was exactly what Mr. Bond had said, though with different intent. Mr. Bond had pointed out that it was requisite to carefully select the tenants, as, otherwise, they would get undesirable ones, and that a superintendent was wanted to see that the regulations were complied with. That seemed to him to be the description of a prison rather than a home, and that was just why costermongers and similar classes of people preferred to live in their insanitary dwellings to going into the sanitary but inquisitorial ones. With regard to the philanthropists who formed companies with a large amount of money, and paid dividends of 4½ and 5 per cent., they could make conditions with county councils, and get land at a far different price to that which the ordinary builder had to pay The consequence was that there was no healthy competition between private and public enterprise. Frequently he had advised friends to acquire some plot that was admirably adapted for artisans' dwellings, but the answer had been that they could not afford to let the rooms under 3*s.* 6*d.* a week. If they went to the Peabody Buildings, they would find that the rooms (built with charitable funds) did not cost more than 1*s.* 10½*d.* to 2*s.* There was no use in investing money under these conditions, for, even if the rooms were let, tenants were certain to move as soon as there was a vacancy in Peabody Buildings. It was antagonistic to private enterprise to compete with public or semi-public funds. Sir Sydney Waterlow made it a boast that they could make more than 5 per cent., but they only gave shareholders 5 per cent., and no more. It seemed to him time to turn the tide in favour of these companies being placed in the hands of the trustees. As to the character of the tenants, it so happened that there was a block of buildings at Canonbury almost identical with the plan of Dr. Sykes, which had been intended for the artisan class, the outside rent being 2*s.* 6*d.* per room. But all these buildings were *not* occupied by the class for which they had been intended. There were no inquisitorial conditions. All they wanted were people who were respectable and paid the rent. There was the usual inspection every six months to see that the repairs were attended to. To his astonishment, he heard music going on in these buildings, and he found them to be occupied by clerks, and so forth. Referring to working men's houses in suburbs, arrangements should be made with the railway companies to enable the occupiers to recoup themselves for the time and money required by travelling.

Dr. Grimshaw, Registrar-General for Ireland, said that comparison of the experiences of various towns was of the greatest importance, and he would give them his experience with regard to Dublin. Most of what he had so far heard related to London, where altogether different circumstances prevailed, the area between the city and the suburbs of Dublin being perhaps one-twelfth that of London. His remarks might also be of interest to the other towns represented. In the first place, the artisan must live near his work, not necessarily in distance, but in point of time. The cost of covering a great distance was counterbalanced by a heavy rent in town, and the expense was, therefore, the same thing. For the artisan's health, however, it was better to live out of town. The Dublin Artisans' Dwellings Company had been founded some 17 years ago, with a view to carrying out the Act which had just then been passed. They had commenced with a capital of 50,000*l.*, which had been gradually raised by subscriptions and loans to 200,000*l.* They had tried both block

buildings and cottages, the result being that the cottages had been much preferred, and they also paid better, for two reasons. The first reason was greater economy in construction; and, in the second place, it had been found that the tenants deserted the blocks for cottages if any cottages were built within a reasonable distance of blocks. People were quite willing to pay more rent for a cottage than for rooms in a block. The result in one portion of Dublin was that the company actually had to reduce the rent of blocks in order to enable them to compete with their own cottages erected in the vicinity. The company paid a dividend of 4½ per cent., and had a considerable depreciation fund. He wished to mention these points specially, as there seemed to be some sort of controversy as to which was the best form of house for the artisan. Dublin artisans undoubtedly preferred the cottage, in which they took more interest than in blocks, and which they liked to make homely by little decorations. He might mention that the reason why he was so intimately acquainted with the interior and the little artistic efforts was that for some years a prize was offered for the best kept house. Anyone who chose to put his name down for these prizes was enrolled, and he had undertaken to act as chairman and organiser to go round these places and examine them, the result being that the cottagers invariably beat the inhabitants of the block habitations for tidiness, neatness, artistic arrangements, and for window gardens and flowers. Therefore, he was one of those who believed in the moral influence of things of that sort, and, morally he thought cottages were a superior method of housing the working classes to block dwellings. He would mention that the death-rate in these houses was singularly low as compared with that of the whole of Dublin, but Dublin was unfortunately, a town with a very considerable death-rate. The width of streets was a matter which came only slightly into question in Dublin, because it was not the habit there to build very high houses, owing to the fact that ground rents were not as dear as in London. However, as a medical man, he looked upon the width of streets as one of the most important elements in the matter of health. It was not merely a question of air-space that was involved, but also a question of light. Human beings were as much dependent upon light for their health as plants, and would come into a half-starving condition without sufficient light and air-space as the latter. The question appeared to be whether the housing of the working classes was to be carried on as philanthropy, as business, or as a mixture of both. His opinion was that enlightened business companies who had regard for fair dealing with their tenants possessed quite sufficient philanthropy, and yet worked on sound business principles, and he considered that the plan adopted by the Corporation of the City of Dublin in dealing with the problem was founded on the best principles. The Dublin Corporation provided nightly lodgings, single rooms, and dwellings for very poor people, either single or married without children. They had also supplied small cottages at very low rents, limiting these according to the circumstances of those who occupied them, on the principle that this part of their work was, in fact, in the nature of philanthropic efforts to assist these people.

Mr. Councillor Atha, Leeds, said he had understood, two days previously, that the question of back-to-back houses or cottage dwellings *versus* flats or blocks was to have been adjourned to the present sitting. He did not know what his friends might think of him if he stated that he lived in a district populated by 75,000 people, and that 75 per cent. of the houses were back-to-back ones. But he wished gentlemen to understand that

there were back-to-back houses and back-to-back houses, and those constructed in Leeds must not be compared with the old-fashioned ones,—badly spaced, with dirty corners, &c. They were constructed on sound principles, with good sanitary arrangements for cleanliness, the prevention of dirty corners, &c., and the death-rate of his district had been almost the lowest of the borough when the last figures were taken. It was 18 and a fraction, whilst in other districts it was over 22. Mr. Atha, assisted by an illustration on the black-board by the Chief Inspector of the Leeds Corporation, explained that there were blocks of sixteen houses arranged in two rows of eight each, and separated in the middle by a space of 15 ft. wide. That space contained the closets for the sixteen houses. The streets running round the blocks were 36 ft. wide, and were well looked after. He was very much startled to hear anybody advocate erecting great buildings for the working classes in London, because there was a danger in throwing too many human beings together. Their system of back-to-back houses distributed the population over a large surface, and if properly built, the whole of the blocks could be kept as dry and well ventilated and as healthy as any other houses. If they forced upon the working population houses at higher rents, they would pay as long as they were in good employment, but with lack of work setting in they could not pay. Their principle of giving the men cottages, even if built back-to-back, made them saving and thrifty, because they felt they had homes in their cottages. There were hundreds and thousands in Leeds who strained every nerve to purchase the freehold of their own cottages. Under other systems all the individuality would be driven out of them.

In answer to various questions by the **Chairman,** the Chief Inspector of Leeds said that every house was self-contained, except the conveniences There were two bedrooms, two sitting-rooms, kitchen, scullery, and a spare room. Every room had a window.

Mr. Gordon Smith said he was very anxious that the gentlemen from Leeds should not go back to Leeds under the impression that back-to-back houses were at all admissible. He thought that question had been quite settled, and he was prepared to show that there were no advantages and a great many disadvantages, in back-to-back dwellings. As regarded cost, there was practically no difference, as no more than the requisite conditions were insisted upon. As regarded the difficulties they had to deal with at Leeds, he knew that they were acting under an Act of Parliament, but that could be altered very easily if there were a desire to that effect. That had been done in Liverpool, Manchester, Birmingham, and other important towns.

The Chairman (Mr. Blashill) held that every kind of view had now been well discussed, and he would now use his privilege of making some observations. It was quite true that a large percentage of the population in any kind of town was desirous of rising and of improving their homes, and, as a general rule, did very considerably rise. But, unfortunately, there was also a number whose tendency was exactly in the opposite direction, whatever kind of accommodation was offered to them, and with them there was the trouble. There were good, bad, and indifferent everywhere; but the young wanted teaching, and, therefore, the principles advocated by those in power must be the very best from every point of view. Every class of habitation wanted supervision as far as it was found necessary. If it were shown that the higher classes neglected their habitations, they would also have to be supervised. He could not agree with

those who spoke so strongly about the impossibility of supervising the erection of houses. If they gave the local authorities sufficient power, they would exercise it with care and tenderness. The officer appointed was too often in the painful position of being obliged to pass building which he would have wished not to pass. In his opinion the authorities of great and important communities should have the power of fixing the lowest scale of accommodation, an irreducible minimum, in which any of their members should live. That might seem a radical proposition, but sooner or later it would have to come to that, even for "unskilled" labourers. He did not know what "unskilled" labour meant, unless it referred to people who could not do anything. He knew of no labour that did not require some skill, and they were not going to erect wretched buildings simply because a certain small class of the population did nothing, and could not work, and called themselves "unskilled labourers." As to the kind of houses in which people should live, there was a diversity of taste as of means. Some people liked to live in a block, or let them call it "residential flats": it might suit them; others might prefer a house. It was simply a question of £ *s. d.* It had been said that land was dear, but then wages were high. There was no place in Europe, he ventured to say, where so much food and clothing and other commodities could be got for so little money as in London. What they had to do was to increase the wage-earning power of the individual, and not to encourage him to say that he was ignorant and therefore compelled to live poorly. More money must be got, not the accommodation minimised. As to height of buildings, the rule in the London County Council now was not to let buildings go higher than four stories, and the Council had now land to dispose of for such buildings. One gentleman had spoken about taking away factories from towns; but towns were not meant primarily for residences, and secondarily for factories; but, in the first place, for work, and in the second place, for residences. He would not live in London, nor in any town, if he had not work to do there, and therefore the idea of doing away with the factories was fallacious. They must make the dwellings healthy, and the factories wholesome places to work in. They had heard what the gentlemen from Leeds had to say about back-to-back houses. He regretted exceedingly to have heard such a story. The feeling in that room was one of distinct disapproval, and he hoped that they would take this lesson back to Leeds with them. From what he had gathered, Leeds had not adopted the Public Health Act in those points which dealt with back-to-back houses. If 75 per cent. of the people of Leeds lived in such houses, and had to put up with all these unhealthy arrangements, it was a lamentable state of affairs, and he thought it was not the kind of thing that would commend itself to the section.

Mr. Rowland Plumbe said he was rather anxious to state that he did not for one moment wish to say that block buildings could be done away with. Mr. Bond seemed to think that his opinion was entirely in favour of village homes, which, however, he knew to be an impossible plan. He would say, however, that the more we got our working-classes into fresh air, and to live in homes of their own, the better it was for us and for them. He would like to call attention to the necessity for legislation in order that third-class passengers might be treated on the same footing as first and second-class passengers. Cheap trains up to half-past five in the morning and, perhaps, double the fare two hours later, were of very little use to the majority of workers. If pressure could be brought

to bear upon the railway companies to give cheap fares to third-class passengers, a great problem would be solved as to housing the working classes in village homes.

Dr. Sykes said that the requisite conditions for light, air-space, and everything else could be observed in block dwellings, as in other classes of dwellings. But there was no legislation for the control of the construction of this class of dwellings, although they required particular control. They might build the largest building nine stories high, with 300 sq. ft. of open space, which was monstrous. That was done in the metropolis, and they would admit that this was a serious question, and that something must be done. He moved the following *Resolution*:—

"That special legislation is requisite for the control of the construction of block dwellings for the industrial classes in cities."

This was seconded by Mr. Plumbe, supported by Dr. Wilberforce Smith, and agreed to.

Friday, 14th August, 1891.

The President, Sir Arthur Blomfield, in the Chair.

English Isolation Hospitals.

BY

Dr. R. Thorne Thorne, M.B., F.R.S., F.R.C.P.

The statutory methods adopted in England and Wales for the promotion of public health may, for administrative purposes, be divided into two classes:—1st, those which are purely permissive, their adoption being left to the discretion of the local sanitary authorities; and 2nd, those which the Central Government have the power of enforcing in cases of default. The former constitute numerically the main bulk of the sanitary measures adopted in this country, and to this class belongs the provision of hospitals for the isolation of cases of infectious diseases, the statutory enactment as to which is to the effect that:—"Any local authority *may* provide for the use of the inhabitants of "their district hospitals . . . . for the reception of the sick."—Public Health Act, 1875, section 131. But notwithstanding the voluntary character of the action taken under this section, and the fact that the total cost of procuring and maintaining any such institution has to be entirely borne by the local community for whom it is provided, noteworthy progress has been made in this direction, and the isolation in sanitary hospitals of such cases of infectious fever as cannot properly be isolated in their own dwellings now forms an important and an increasing element in the protection of the public against the spread of "dangerous infectious disorders."

In a report which I presented to the Local Government Board some nine years since, on "The Use and Influence of Hospitals for Infectious Diseases," * I stated that out of about 1,510 provincial sanitary authorities in England and Wales in 1879, 296 possessed some means for the isolation of the infectious fevers, other than that intended for poor-law purposes; and I find that, since that date, loans, amounting in all to 448,769*l.*, have been granted to over a hundred sanitary authorities for the provision of isolation hospitals. Some of these loans, it is true, relate to the replacement of former hospitals by more efficient ones, and to the extension of existing ones; but, on the other hand, a number of isolation hospitals have been erected out of current rates and otherwise than by the aid of loans, and I am probably correct in stating that some adequate means for the isolation of infectious diseases are now possessed by at least 400 urban, rural, and port sanitary authorities; and, it may be added, that there is already evidence that the adoption by a large number of sanitary authorities of the permissive clauses of the Infectious Disease (Notification) Act, 1889—a measure by means of which early and precise information is secured as to the extent to which infectious diseases prevail in any district—is likely to lead to a substantial increase in the number of English isolation hospitals.

Diseases calling for isolation.—The infectious diseases which, in this country, especially call for isolation in hospital are, in the order of their importance, as follows:—Scarlet fever, typhus, small-pox, diphtheria, enteric fever, and cholera; and to these may be added, as being less frequently isolated in hospital, erysipelas, measles, whooping-cough, and puerperal fever. So far, there is no evidence that aggregation of the infectious sick suffering from any of these diseases, except small-pox, such as is likely to be carried out by any ordinary sanitary authority, leads to diffusion of infection to the surrounding community, provided the hospital be properly constructed and administered, and subject to a zone of some 40 feet being provided between all buildings intended to receive infected persons or things and the boundary wall, or close fence, around the site. Experience has shown that it is otherwise with small-pox; and it yet remains to be ascertained what are the circumstances under which cases of that disease can be aggregated for the purposes of sanitary authorities, without risk to the community. Fortunately, owing to the protection afforded by vaccination, small-pox does not, as is commonly supposed, stand foremost amongst the infectious fevers calling for isolation in hospital. As a rule, port sanitary authorities alone make special provision for cholera.

The following are some of the principal points to be kept in view in providing for the other dangerous infectious disorders which have been referred to.

Extent of provision to be made.—Speaking generally, it has been estimated that the provision of one bed per 1,000 inhabitants, is

* Supplement by the Medical Officer to the Tenth Annual Report of the Local Government Board [C. 3290] 1882.—Re-issued 1884.

sufficient for the permanent requirements of a sanitary district. But such requirements will necessarily vary in accordance with the character of the population. Thus, in a locality where the population is well-to-do and most houses are of a size and construction that offer reasonable facilities for the isolation of single attacks of the current infectious fevers, the amount of hospital accommodation needed for public health purposes will be less than in a manufacturing or colliery district, where infectious disease cannot be treated in the houses in which it breaks out without very great, if not certain, risk of spread. As yet, no sufficient experience is available as to the effect of the compulsory notification of infectious diseases on the amount of accommodation which should be maintained for isolation purposes. It may reasonably be expected that in time such a measure will so far prevent the diffusion of infection as to reduce the amount of standing hospital accommodation necessary for the isolation of the infectious fevers. But, as yet, from the experience of some sanitary authorities, and especially as regards such a disease as scarlet fever, the new sources of information of which authorities become possessed have led to an increase in the number of persons removed to hospital, and thus to a need for additional means of isolation.

Character of accommodation required.

Premising that all the conditions which are deemed essential in the provision of a healthy dwelling-house are to be regarded as equally desirable in the case of an infectious hospital, I would only here refer to such other points as involve considerations peculiar to such hospitals.

(a.) *As regards site.*—It is, as a rule, undesirable to select any site which is less than some two acres in extent; and even then regard should be had to the need for extension of hospital buildings, whether for temporary purposes or owing to increase of population. Where practicable, only single-storey hospital pavilions should be contemplated; and having regard to their distribution on the site, and to the out-door exercise of convalescents, 20 patients per acre will generally be found to be the limit of aggregation of sick on area.

(b.) *As regards buildings.*—The administrative building should be distinct from all others. Nurses, when off duty, will live and sleep in it; tradesmen will call there for orders and with supplies; and relations will there make inquiry as to the progress of the sick. This building should always be so placed as to control all access, from without, to the ward-pavilions and other hospital buildings. The laundry, ambulance-shed, disinfecting apparatus, and mortuary should also be in one or more buildings separate from the administrative building and the ward-pavilions.

No sanitary district can be regarded as properly provided for unless it has immediately available sufficient accommodation for the isolation of two different infectious diseases in both sexes, and some means for the special isolation of one or two patients needing separate accommodation, as, for example, cases in which the nature of the disease is, at first, doubtful. These requirements are usually met by the provision of two

pairs of wards or rooms having no aërial communication with each other, together with one or two special isolation rooms. In sparsely populated districts these requirements may be combined in one pavilion the several apartments of which open separately onto verandahs. Such a building is commonly styled an isolation-pavilion.

Each ward-pavilion should admit of cross-ventilation by means of windows in the two opposite side walls; the closets and ward sinks, having themselves independent means of cross-ventilation, should be entered from the wards by means of a cross-ventilated lobby; all angles, vertical and horizontal, should be rounded to prevent deposit of dust, &c.; and a nurses' duty-room should be provided. Assuming that each ward will contain the ordinary proportion of acute and convalescent patients, and that it is adequately ventilated and warmed, a minimum of 2,000 cubic feet of air per head is generally found to suffice in order to maintain reasonable purity of air. But much depends on the allotment of this amount of air to the individual patient. No excess in the amount of total air provided—as, for example, in the case of lofty wards—can compensate for crowding patients on the floor-level; and hence the beds should be so arranged as to ensure for each patient a floor-space of some 156 square feet. And since it is in the neighbourhood of the patients, mouth and nostrils that it is above all important to maintain the purity of ward-air, it is of all things necessary to allot to each bed a separate amount of wall-space, not less than some 12 feet in length.

(c) *As to allotment of bed-space.*—The best position for the beds is that one bed should occupy each wall-space between a pair of windows, the head of the bed to be at least one foot away from the wall, so as to facilitate movement of air about the patient's head.

Medical advice is often sought as to the number of beds that should be placed in any one ward of an infectious hospital. In suggesting an answer to this question, I cannot avoid the conclusion that the practice of treating sick persons under circumstances which admit of the air by which they are surrounded being charged, more or less, by the emanations of other sick persons is wrong in principle, and that from this point of view any aggregation of the sick in wards is undesirable. But other considerations must, in the case of a large proportion of the population, be regarded as outweighing this one; and all that can properly be contended for is, that the limit of such aggregation shall be decided by considerations such as are involved in securing freedom from any recognisable risk, together with such efficiency in general administration and nursing as is consistent with a reasonable regard for economy.

The several infectious fevers, doubtless, differ in regard to the amount of nursing which the sick require; but taking them as a group, and assuming that the ordinary proportion of acute and convalescing cases at varying ages are brought together, it may be held that any one nurse can rarely be expected to take charge of more than 12 patients. The moment this number is exceeded, the nursing staff has to be doubled; and directly a second nurse is required, it would be better in the interests of the sick, that those whom she nurses should

be in a separate ward. Holding this in view, I believe it will generally be found desirable that infectious hospitals should be built in pavilions so contrived that in each there shall be two wards, one for males and the other for females, containing together not more than 12 beds; the two six-bedded wards to be separated by nurses' duty-room and an entrance lobby.

The principles which have been laid down are embodied in the Memorandum as to Isolation Hospitals, issued by the Medical Officer of the Local Government Board; and they are those which now govern the construction of nearly all modern isolation hospitals in England and Wales.

The Heathcote Hospital, Leamington.

BY

KEITH D. YOUNG, F.R.I.B.A.

This hospital was erected in 1889 by the Warwick Joint Hospital Board, the constituent authorities of district being the urban districts of Leamington Spa, Warwick, Kenilworth, Lillington, and Milverton, and the rural sanitary district of Warwick Union. Since the formation of the joint district the districts of Lillington and Milverton have been amalgamated with the borough of Leamington.

The site is six acres in extent, two and a half acres of which are enclosed and appropriated to the hospital use. It stands on the high ground in the middle of open fields, and is about midway between the towns of Warwick and Leamington.

The population within the joint district was, when the hospital was erected, about 55,000, and of this number some 44,000 were within a radius of three miles from the hospital site.

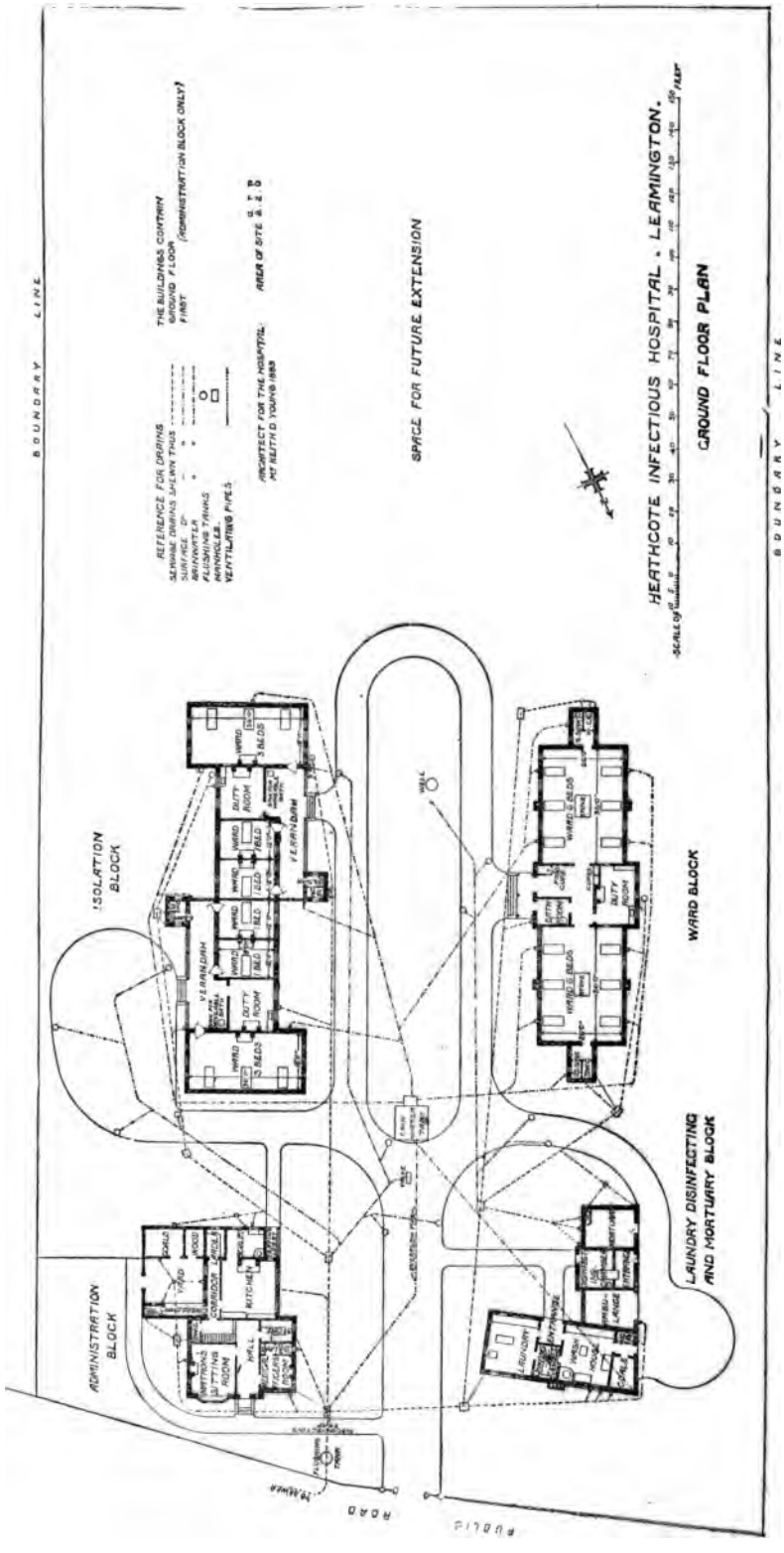
The area of the district is 44,507 acres, and its rateable value 340,000*l.* The accommodation provided is equal to one in every 2,000 of population.

The buildings are four in number, and each is entirely detached from the remainder. They are:—

1. The administration block;
2. The isolation block;
3. The ward block; and
4. The laundry block.

The site is enclosed on three sides by a high wooden fence; the front towards the high road having a dwarf wall and an iron railing.

The two blocks occupied by patients, and the laundry block, are each 40 feet distant from the boundary, and an inner fence at a distance of 40 feet from the front gates prevents patients from approaching too near the latter.


HEATHCOTE INFECTIOUS HOSPITAL . LEAMINGTON.
GROUND FLOOR PLAN
SCALE OF FEET
BOUNDARY LINE
SPACE FOR FUTURE EXTENSION
REFERENCE FOR DRAINS
THE BUILDINGS CONTAIN
GROUND FLOOR
FIRST (ADMINISTRATION BLOCK ONLY)
AREA OF SITE
ARCHITECT FOR THE HOSPITAL
MR KEITH D. YOUNG 1933
ISOLATION BLOCK
ADMINISTRATION BLOCK
WARD BLOCK
LAUNDRY DISINFECTING AND MORTUARY BLOCK
VERANDAH
WARD 5 BEDS
WARD 2 BEDS
DUTY ROOM
KITCHEN
MATRONS SITTING ROOM
HALL
LAUNDRY
WASH HOUSE
DISINFECTOR
MORTUARY
ROAD

The administration block is the only one of the four buildings two storeys in height, the rest being one storey only. It contains on the ground floor a sitting-room for the matron and nurses; a room, with a lavatory and w.c. attached, for medical officers; linen room, w.c. for nurses, kitchen, scullery, and larder, with wood and coal stores, and servants' w.c. in the yard. At one corner of the kitchen is a serving hatch opening into a covered porch at which the meals for the patients are given out.

On the upper floor are bedrooms for the matron, nurses, and servants, and a bath room.

The isolation block is divided into two equal parts by a wall, and the arrangements on one side of the wall are an exact counterpart of those on the other side, the entrance to one side being on the east, and that to the other side on the west.

Each half of the building, therefore, contains a large ward for three beds, two small wards for one bed each, a nurses' duty room, and a w.c. and slop sink. These rooms communicate with each other by way of an open verandah, roofed over at the top, but quite open in front.

Each large ward is 36 feet long by 18 feet wide, the smaller wards being 18 feet by 12 feet, and all are 12 feet high. The allowance of floor space is 216 feet per bed, and of cubic space 2,592 feet per bed. The large wards are lighted by three windows at each end, the smaller ones by one window on each side, being in the proportion of one square foot of window surface to about 65 feet of cubic space. The windows, which form the principal means of ventilation, are divided into two parts by a transom which is fixed about 1 foot 6 inches down from the head of the frame. Below the transom are ordinary double hung sashes provided with a deep bottom rail and a cill board which permits of the lower sash being raised and a current of air admitted in a vertical direction between the two sashes, at the same time preventing free access of air at the cill level. Above the transom is a "hopper light" hung on hinges at the bottom to fall inwards, and provided with glazed cheeks at the sides to prevent down draughts.

In addition to the windows, openings are made at the floor level behind each bed, and provided with Ellison's radiator ventilators; there is also an extraction flue in each ward carried up alongside the smoke flue from which it is separated by iron plates. The inlet to the flue is at the ceiling level, and a Bunsen burner is provided with a view to produce an upward current when the fire is lighted.

The wards are each provided with a Boyd's hygiastic ventilating grate; these grates have at the back of the fire an air chamber which is supplied with fresh air from the outside. The air being warmed by contact with the heated fire-brick back of the stove passes into the room through a grating above the fireplace.

The walls of the ward are lined to a height of 5 feet with tinted glazed bricks, above which they are plastered and distempered. The floors are laid with yellow deal in 3-inch widths, ploughed and tongued.

The vertical angles of the walls, the horizontal angles at the junction of floors and walls, and of walls and ceilings are all rounded, so also are all the angles of door panels and of the windows and in the finishing of the doors and windows rounded fillets only are used, no recessed mouldings being used anywhere.

The nurses' duty room is provided with a small range with oven and boiler, and hot water is laid on from the latter to the sink, the movable bath, in corridor, and the slop sink. There is also in this room a small dresser, and a glazed porcelain sink.

Outside the duty room is a recess, where the movable bath stands. A glazed fireclay sink let into the floor takes the waste, and taps fixed to the wall afford the supply of hot and cold water.

The water-closet and slop sink are placed in projecting buildings, entered from the verandah. The walls of these offices are lined with glazed bricks, and the floors are of cement. The slop sinks are of porcelain, provided with a flushing rim, in addition to the hot and cold water taps. The closets are Hellyer's pedestal hygienic, the trap and basin being made in one piece of porcelain, and are fitted with 3-gallon flushing cisterns, and hard wood rim seats hinged at the back.

Ward Block.—This building is entered from the centre, and affords accommodation for 12 patients, all of one disease, the beds being equally divided between the two sexes. In the open porch at the entrance are two doors; one of these gives access to the entrance lobby, the other being an outer door to the bath room. The object of the latter is to enable a patient on being discharged to leave the building directly from the bath room. The bath room thus becomes a discharging room; not perhaps an ideally perfect arrangement, but certainly a better one than if the patient had to re-enter the ward after his final bath.

To the left of the entrance is a smaller cupboard with a window for food, and opposite are cupboards for patients' clothes and linen. Between the wards is the nurses' duty room, in which is a small range with boiler for supplying hot water to the bath, sinks, and lavatory basins, a dresser, and a porcelain sink.

The wards are each of them 36 feet long and 26 feet wide, and contain six beds each. To each bed is allotted a floor space of 156 feet, and a cubic space of 2,028 feet, and the distance from centre to centre of each bed is 12 feet. The window area is in the proportion of about 1 foot of window to every 60 feet of cubic space. The means of ventilation are similar to those adopted in the isolation block. The grates also are similar, but in these wards are placed in pairs, back to back, in the centre of the floor, with descending flues carried under the floor to vertical chimneys in the outer wall. The latter are swept from the outside.

The water-closets and slop-sinks are placed in the projecting buildings at the end of the wards, from which they are separated by cross ventilated lobbies.

The construction of these wards as regards internal finlshing of floors and wall surfaces, &c., is in all respects similar to that of the isolation block.

A speaking-tube connects the duty room with the administration block.

The laundry consists of a wash-house fitted with the usual appliances for washing, an ironing room and a drying room heated by the flue of the ironing stove, and fitted with a radial drying horse. Adjoining is a w.c. and a coal store.

The disinfecting house is divided into two parts by a brick wall. The apparatus, which is one of Washington Lyon's high-pressure steam machines, projects on each side of this wall, so that the infected clothes are put in in one chamber and when disinfected are taken out by the door in the other chamber.

The mortuary is a plain sky-lighted room, arranged for use, when necessary, as a post-mortem room. The ambulance house affords accommodation for a one-horse ambulance.

DRAINAGE AND WATER SUPPLY.—The drainage system is a dual one, the rain-water being separated from the sewage and stored in a tank for use. The drains are all laid with glazed stoneware pipes jointed with cement, with manholes at each junction and change of direction. Each length of pipe between the manholes was separately tested with water before being covered up, and all the pipes are laid on and partly embedded in concrete. At the head of every length of drain is a Doulton's 30 gallon automatic flushing tank, and at the outfall to the public sewer is a large flushing tank fixed by the town authorities. These flushing tanks were specially necessary in this case, as not only is the quantity of sewage discharged at one time necessarily small, but the sewer conveying the hospital sewage to the town sewers has to traverse a long distance before it comes near any other buildings. The soil pipes are carried up above the eaves of roofs their full diameter as ventilating shaft.

The rain water from the roofs is all collected into an underground tank, first passing through a filter chamber formed partly of coarse and fine gravel, and partly of charcoal. From the tank it is pumped for use in the scullery of the administration block and the wash-house.

The cost of the hospital was as follows:—

	£	s.	d.
1. Land	900	0	0
2. Buildings, including laundry fittings, disinfecting apparatus, roads, paths, fences, drains, and professional charges	7,635	10	6
3. Gas mains, from nearest point up to site	84	4	4
4. Water mains	161	10	11
5. Sewer	299	4	9
6. Furniture	293	17	7
	£9,374	8	1

To meet this outlay loans were obtained from the Loans Commissioners to the extent of 9,316*l.* at 3½ per cent., repayable in 30 years. The interest and repayment of principal amounts to an annual sum

of 630*l.*, which is met by a rate equal to seven-sixteenths of a penny in the pound.

As regards cost of maintenance it is not very easy to arrive at a definite figure in regard to a hospital which is liable to be occupied or not in so absolutely uncertain a way as this; but assuming the wards were empty for 12 months continuously, it is estimated that the cost of maintenance for that period would amount to 370*l.* This sum includes the following expenses:—clerk, medical officer's retaining fee, steward, matron, caretaker, out-door porter, nurse, rations for residents, coal, gas, and water, rates and taxes. For the statistics as to cost, and for much valuable information I am indebted to Mr. Alderman Wackrill, the Chairman of the Joint Board.

Local Isolation Hospitals as opposed to a Central Hospital.

BY

C. E. Few, Vicar of Seal, Sevenoaks.

It seems to me a question well worth considering, whether it is not on the whole far better to treat fever cases in the locality where they arise rather than to transport them to large central hospitals. I am speaking only for country districts, having no experience in towns; possibly there large central hospitals are best.

It is of course impossible to go into such a vast subject as this in the brief time allotted to those who have the privilege of reading a paper at such a Congress as that now assembled. It is only just possible to treat of some of the great pros and cons, and so leave the public to decide whether or no the present system is unwise, and needs consideration, and perhaps alteration.

All hospitals require careful management and supervision; this of course is possible in ordinary hospitals, as committees of laymen can visit and judge for themselves. In fever hospitals this is more difficult, especially in country districts. The hospital being probably placed in some out of the way place, and rarely visited by any except those in charge; the outside public being practically excluded. Local hospitals would naturally be more under supervision.

It is of the utmost importance to make the hospital system popular, because notwithstanding all Acts of Parliament, poor people cannot be compelled to have doctors at all; and many a case has been and will be hushed up and treated at home, particularly when children can be compulsorily removed to some out of the way distant place, to which the parents would have to walk and lose a day's pay if they wished to inquire.

Local hospitals would certainly minimise this difficulty; the position would be known; kindly local interest would probably do its best to make each hospital as complete and attractive as possible; and

the residents would have the feeling that all care expended on the hospital would be for the benefit of their own poorer neighbours; and the cottage owners in the district should be taught, that by arranging for local treatment they were but providing that spare room accommodation which they are able to enjoy in their own houses, but have, as a rule, failed to provide for their cottagers.

It must not be forgotten that the removal of patients can only be enforced where there are not *means for isolation at home.*

A large central hospital is doubtless damaging to the value of property, not only in the immediate neighbourhood, but in the district generally, inasmuch as all the fever of an area of perhaps some 15 or 16 miles in breadth is liable to be carted into it along the country roads.

If the fact of this central hospital would free the rest of the district, the argument that some rather than all should suffer might very properly be urged; but no one *pretends that this is the case,* doctors only speaking of moving about 60 per cent. of the cases; and if only five per cent. is left behind, it is enough to start all the mischief over again.

The ambulance risks are twofold; to the patient, and to the neighbourhood.

No bad case could be moved at all, certainly not for any great distance; and surely the risk of conveying infected people through village streets and amongst the ordinary curious people of the world must be dangerous; and certainly the law as to a zone of 40 feet cannot be observed.

The cost of a permanent hospital unoccupied must be a very heavy charge, and this, possibly, for months together.

Alternative Scheme.

The alternative scheme I would suggest is to map out every district, and to choose sites suitable for treatment of fever in a certain area; the smaller the better.

To prepare these sites as to drainage and water supply, and to place on each a small iron room, with walls about 8 feet high, to be used as a kitchen and laundry; the rain to be collected in a tank for washing purposes.

The sanitary authority should provide a certain number of portable hospitals, say two for each relieving officer's district, and two extra ones to be kept at the union house on a two-wheeled cart, like a lifeboat, ready for immediate transmission if required, to supplement the two local wards.

These rooms should be capable of holding three, or, at a push, four patients. If cottages could be secured for kitchen and nurse, so much the better; but if not, portable rooms suitable for the nurse should be provided, one for each relieving officer's district.

These sites might be in meadow lands, 40 feet from the road, the iron room surrounded with a barbed iron fence sufficient to enclose

it, with the understanding that, when occupied, the zone of 40 feet, if considered necessary, should be wired off. The nearest point on the road could be, when required, connected by a wire to run a basket on wheels for the transport of goods, and at very little expense a pipe could be laid from the road to supply drinking water from a water cart. The drainage should consist of two cesspools ready dug, one for slop water, the other for the infected sewage; the earth excavated should be kept dry and available for earth closets.

On these sites should be erected the portable rooms when required.

Should any kindly landowner wish to provide a site for his own particular district, in addition to the public one, he shall be allowed to do so on fulfilling the above conditions, and be supplied with the portable wards, *on the understanding* that his site becames, *pro tem.*, the official centre of fever for that area, and that all cases in that area may be brought into it during that outbreak.

By this means the whole district would have, as it were, skeleton camps arranged, and all provision made for invasion of disease, costing a mere trifle when unoccupied, and capable of almost unlimited expansion.

In case of a very severe outbreak, the medical officer of health can requisition the wards from other districts.

The Wards.—These should be bright, warm or cool, with non-absorbent walls, capable of frequent changes of air without draught. No better material is to be met with than that made by the Patent Wire-wove Waterproof Roofing Company, a strong wire-wove material, waterproof, tough; giving, when painted, a smooth glazed surface, most easily cleansed and disinfected, and a good non-conductor of heat.

The walls and roof should be double, with air space between, and the system of ventilating by Tobin tubes freely introduced. If the air can be frequently changed without inconveniencing the patient, there is not the same necessity for so large cubic space per patient.

The question of a room being too hot or too cold depends in a great measure upon its scientific construction, and the material of which it is made. Ice keeps better in lead than iron; a blanket would keep a can of water hotter, and a lump of ice longer than if either were placed in a brick cupboard; and even paper blankets are warm, or to speak more correctly retain the body heat. Hence, if you can find a good non-conductor of heat, however thin it may be, and construct the room with double walls and roof, with air space between, it would be possible for the temperature of that room to be very little affected by the outside temperature. Such a room could be kept warm by stoves in winter, and ought not to be baked by sun in the summer. A brick room exposed to the baking sun takes all the night to cool, whereas a thinner material would soon radiate the little heat it held.

In the Local Government Report, in speaking of temporary hospitals, cases are mentioned of patients dying of cold, and of water

freezing in rooms; the latter sometimes happens in well-built private houses; but if it does it must be somebody's fault; bad construction of room, insufficient warming apparatus, or inattention to fires.

Nor, again, need these portable buildings be heavy; a little science helps one in the construction, and a determination not always to build in the same groove.

I built a hospital that weighed only 13 cwt., 16 feet by 12 feet; three or four navvies had small-pox in it in one of the most exposed spots in Kent. I erected it myself in a storm of snow and hail about five years ago. Before it was erected on the spot one of the largest London builders sent his foreman to see it, who rather laughed at the slightness of my timbers. He went away and supplied a house, supposed to be like mine, using timbers at least three times as heavy. His house blew down in about a week; mine never did.

Unnecessary weight is a great mistake, particularly in a portable hospital. Thick timbers only warp and hold the damp; all you want is strength enough, and that judiciously applied.

These houses of wire-wove material can be constructed for about 6*s*. per square foot of floor, calculated to last for 20 years, at the cost of painting once in four. One, say 24 feet by 12 feet, could be erected in about 12 hours.

There is not, as a rule, such a desperate hurry; a doctor is cautious in pronouncing as to *the first* case of fever, and after the announcement there is always a certain amount of unavoidable delay before action can be taken.

It might be wise to engage one skilled nurse for the union; but this is not absolutely necessary. No difficulty has hitherto been experienced in procuring fever nurses when required. Moreover, in country districts, months of idleness and making gossiping acquaintances would be undesirable. A nurse in thorough training, and one who knows nobody is always the most efficient.

We come now to the relative cost. I take an estimate for a central hospital, say 2,500*l*. for 12 beds, because these figures have actually come before me, and are probably as moderate as possible, representing in the particular instance about 6*d*. per cubic foot. This figure included no water supply or purchase of site.

	£
Hospital for union, consisting of three relieving officers' districts, to hold 12 beds - -	2,500
	£2,500

That is, about 208*l*. *per bed.*

Six Portable Hospitals for same district (two for each district) about 70*l.* each - - -	420
Two extra ditto, 70*l.* each - -	140
(These hospitals, holding three beds each, would make up 24 beds).	
Three houses for nurses - - - -	75
Preparing three sites, say 20*l.* each - -	60
	£695

Say 800*l.* for 24 beds; about 33*l.* *per bed*, or *one-sixth of cost* as compared with central hospital.

In my next remarks, I hope I shall not be misunderstood to be wishing to impose on my medical friends any additional gratuitous work.

There is no profession in the world, the members of which give up so ungrudgingly so much valuable time and energy to alleviate the ills of mankind as the medical profession, in England, or on the Continent, or in the civilised world.

I am treating the matter purely as a business question; and I am only endeavouring to provide local hospitals where patients can be treated far better than in their own homes. I am also assuming that most doctors would rather keep their own patients than send away to a distance where they could not possibly find time to visit them.

Central hospitals are attended either by a resident medical officer or else by some local practitioner, who for a fixed sum, say 10*l.* or 20*l.* per annum, and 1*l.* per case, undertakes the charge of the hospital.

In the local hospital system there would be *no medical fees or charge for drugs whatever*.

Patients would be of three kinds: those treated by their own doctors privately, those on clubs, those under the parish doctor. Hence, fever cases would be only a part of the duties of the medical men working in the district, and nothing could be charged to the ratepayers.

For argument's sake, assume the moderate number of 50 cases: under the central system there would be a charge on the lowest estimate of 60*l.* per annum, under the local system NOTHING.

This amount saved per annum would alone in 20 years renew the whole of the portable hospital wards and leave 400*l.* to the good.

People say that if there is so much difficulty in providing one site, so much greater will be the difficulty to provide many. On the contrary, I believe the smaller you make your area, the less will the opposition become. We do not mind nursing our own children in our own houses, but we should strongly object to having the children of others thrust in upon us. The ills of our neighbours, even from selfish motives, we are glad to endeavour to alleviate, and for them we might even run risks; but we are not called upon to do this for people living at a distance, just because their own neighbours will not look after them and provide the needful accommodation.

DISCUSSION.

Dr. Fosbrooke, Medical Officer of Health, Worcestershire County Council, said that the Worcester County Council directed the administration of three permanent and three temporary hospitals. His experience was that the latter were no more unsafe than the former. A fever hospital, like a fire-engine, in order to be efficient for its purpose must always be kept ready for instant use. It must be ready to receive the very first case of contagious disease that broke out. The reader of the last paper spoke of permanent hospitals as if they were always inaccessible. It was not uncommon, in his experience, for patients to go eight or nine miles to an isolation hospital, and he had never known of a case of injury arising in passing through towns and villages, or where the journey had caused the patients to suffer. He could not agree with Mr. Few that temporary hospitals would be more popular than permanent ones. Parents would readily enough send their children to a hospital where they were assured that the child would be better treated and receive more care than at home. The children also were very glad to go. There need be no delay in removing patients; it was only necessary to telegraph when a case broke out, and an ambulance was sent at once. At Droitwich they were going to do away with the temporary hospital in favour of a permanent one.

Dr. Nasmyth (Sanitary Association of Scotland) said he wanted to organise in his part of Scotland (Fifeshire) a combination hospital, in which the principles of the cottage hospital and of the isolation hospital could be conveniently combined. He would like to ask Dr. Thorne if he saw any objection to such a combination. He wished to know also what distance he would consider safe for the removal of cases.

Mr. Jeaffreson (Framlingham, Suffolk,) described the arrangements in practice at an isolation hospital at Framlingham, which had been formerly always known as the "Pest-house." It was very seldom they had a case, but they were always prepared, because they gave to the nurse a retaining fee in the shape of a garden and rooms rent free. They had also a permanent hospital, but the only difference between them was that in the permanent hospital beds were kept ready for patients, but in the pest-house there were no beds. Every fresh case required fresh beds, which would be taken away and destroyed when the patient had gone. When the pest-house had no patients it was absolutely empty. In rural districts such hospitals might be empty for years. A double treatment of that kind was the best practical solution of the problem. The nurse's fee would be paid by the parish when it was a parish case, and by friends of the patients when it was a private case.

Mr. T. F. Wakefield (Chairman of Health Committee of the Corporation of Richmond) said Richmond was still seeking a site for an isolation hospital. Several eligible sites had been offered, and would have been bought, but in every case the neighbouring residents protested against the hospital being built. The County Council was about to apply to Parliament for power to deal with the whole county in regard to provision of this kind. In Surrey only one-third of the population was supplied with isolation hospital accommodation. The County Council had interested itself in trying to solve the question whether some danger of infection did not arise from the use of the ambulance itself. Finding that the bearers and attendents were themselves not attacked by infection, they had come to the conclusion that the fear of infection from the use of

ambulances was not justified. The supposed difficulty in getting patients to a hospital was chimerical. With a proper ambulance it was as easy to go 10 miles as to go one. The speaker, in conclusion, called attention to what he said was an excellent brougham ambulance, which could be seen in Long Acre, at Davis's, the coach builder's. Other County Councils would find it necessary to do Surrey was doing, and they would do well to obtain powers from the legislature to deal with the question on a comprehensive plan. The best solution of the question was, in his opinion, a permanent central hospital. In his opinion, no hospital should be considered complete without a complete apparatus for disinfecting by super-heated steam. The expense would be prohibitory if such apparatus had to be multiplied in proportion to the number of temporary hospitals that would be necessary.

Alderman Ernest Day (architect, Worcester,) said he once held the same opinion as Mr. Few, but further experience with temporary hospitals had brought him to an opposite opinion. The prejudice against living near a permanent hospital was dying out, and people were found now ready to build right up to the walls of a hospital. The objections he had against Mr. Few's interesting paper were economical ones. On the score of economy, one central institution was far better than half-a-dozen temporary ones. Each would want a doctor, making six doctors instead of one. Two or three nurses might be sufficient for a permanent hospital, but six temporary hospitals would require six times as many. The materials and all the apparatus, as well as the staff, would have to be multiplied by six, and the sites, however temporary, would be very costly. A temporary building would require to be renewed every 20 years, but a permanent hospital might last for a century.

Dr. J. Maxwell Ross (Officer of Health, Dumfriesshire,) said he had been disposed to recommend six hospitals, viz., one for each of the six districts in his county, instead of one central hospital, and the present discussion would help him to mature his views on a question in which he was greatly interested.

Councillor John Atha (Leeds) said they had formerly found it difficult to dispose of the families of persons removed from their homes suffering from infectious diseases during the period necessary for disinfecting their houses. They had now adopted the expedient of providing a shelter, where the families of infected patients were sheltered and maintained until the doctor was satisfied that there was no danger to be apprehended from allowing them to return home. At first, the County Council exacted payment for the accommodation, but eventually they had decided that the public should bear the whole cost, since it was primarily for the sake of the public health that these people were forced to leave their homes temporarily. It was still a moot question with them whether it was not more economical to put up wooden buildings, which could be burned down when no longer wanted, or to build more permanent structures.

Dr. Thorne-Thorne, in replying, said he was so much in sympathy with Mr. Few in principle that he was sorry to have to differ from him *in toto* with respect to method. His plan of multiplying temporary hospitals would be a most expensive one, and it would probably be found that when everything necessary had been supplied to his temporary hospitals, ten times the estimated cost would be incurred. Dr. Fosbrooke had always been a difficulty in the way of the advocates of permanent hospitals, because his establishment seemed to be so successful, and was

so well conducted as almost to amount to a refutation of their arguments. Now that even Dr. Fosbrooke admitted failure, the question was settled. If wood were used in the construction of temporary hospitals they should be burned down; but they never were. The wooden buildings were left to rot on the ground, and he could show samples of wood from such structures which would horrify any sanitarian. A proper ambulance would be an excellent thing. It should be of simple construction, and should only require two movements in order to load and unload the patient—one push to get him in, and one pull to get him out. To properly warm wooden hospitals was very difficult. He had in mind such a hospital where, although they had killed two patients with the heat, they could not, even with roaring fires, prevent water from freezing at the bedsides of the patients. They must have thick walls if they were to keep out the cold in winter. In summer there was nothing like tent treatment. Permanent hospitals ought to be solid buildings, well constructed, and attractive.

The Rev. Mr. Few, in his reply, said he was satisfied to have been able to bring his scheme forward. No one had been able to dispute his main facts. Before a sound conclusion could be arrived at, the question would require mature discussion by the public. With regard to sites, they could often be arranged for in advance, to be only actually purchased on a future emergency. He had found that plan practicable in his own parish. Richmond was a town where the distances were small, and certainly a central hospital was best in such cases.

The Arrangement and Construction of Asylums.

BY

RICHARD GREENE, F.R.C.P., Ed., Medical Superintendent, Berry Wood Asylum, Northampton.

If it be desirable that the greatest care and judgment be brought into action in the construction of all large buildings, it is imperative that asylums for the insane should be above the suspicion of fault. Here large numbers of patients are kept in confinement. They have had no choice in selecting their place of residence, and no voice in fixing the duration of their stay. They are suffering from one of the greatest, perhaps *the* greatest, affliction that can befall a human being, and common justice requires that their terrible calamity should not be increased by unhealthy surroundings; but, on the contrary, that all the aids of hygienic and other sciences should be called in to lighten their burden and promote their cure.

It is sad to think of the condition of the insane in olden times. Suitable provision was not even dreamt of. Old prisons, monasteries, or, in fact, any building not good enough for anything else, was the lazar-house into which the poor lunatic was consigned. Indeed, it was not until the dawn of this century that the subject was seriously con-

templated with a view to reform, and by far the greatest strides have been made during the present reign—the Victorian era—which has to be credited with so much that is good in all departments of our civil life.

It may be said that the old asylums were simply conglomerations of buildings, without attempt at harmony, architectural effect, or hygienic conditions. Few examples of these exist in England at the present day, but in some continental countries they are common enough yet. During the early part of this century an Act was passed which rendered the building of county asylums, and of making adequate provision for the insane poor, incumbent on the various quarter sessions throughout England. It is impossible to refrain from stating that this duty was in most instances admirably performed by the county magistrates, and the modern English county asylum is an institution which is in all countries looked on as a model, both as regards construction and system of management. The visitor who for the first time inspects some of our provincial asylums will be struck with the beautiful sites which have been selected for them; with the carefully laid out grounds and recreation courts; their comfortable, almost luxurious appearance, and with the freedom which the patients almost universally enjoy.

The only building to which a modern county asylum can be compared is a general infirmary, and even here there are many points of difference. These points are more noticeable on an internal inspection than on an outside view, and they are caused by the different objects which have to be kept in sight when the buildings are being designed. A very good hospital might prove an indifferent or even bad asylum, and a good and well-planned asylum would be a second-rate hospital. The grand distinction between the two is that in the hospital the majority of patients are in bed during both day and night, whereas in asylums the majority are up by day. Also, an infirmary does not require single-bedded rooms, while in an asylum at least one-fourth of the numbers should be accommodated in rooms having only one bed. These conditions render the designing of an asylum a much more complicated work than that of an hospital.

The site of an asylum should be carefully selected, and a gravel soil obtained, if possible, but inasmuch as an asylum should occupy a position somewhat centrally disposed to the population from which it draws its patients, it is evident that the desirable soil cannot always be obtained, at least it cannot always be had at a reasonable price. When, therefore, the building has to stand on clay, the most careful and thorough subsoil drainage must be carried out.

Some authors have described a variety of insanity as "phthisical insanity." Whether it is perfectly correct to so describe it I am not at all sure; but it is certain that the insane suffer from tubercle more frequently than the population generally; and as it has been proved that sub-soil drainage lessens the mortality from consumption, the point needs no further argument to enforce it. The group of diseases coming under the name of "rheumatism" is also greatly modified by the nature of the soil.

In England it is important to avail ourselves of every gleam of sunshine vouchsafed to us. A southern aspect should therefore be insisted on, and the building should be placed on gently rising ground not too high above the sea-level, as exposed sites are apt to be cold during the winter months for an invalid's residence.

The amount of land should be sufficient to protect the patients from the gaze of the inquisitive; but a large estate is neither necessary nor desirable. High roads and public footpaths should be at some little distance.

In many districts stone is to be had cheap for building purposes, and in these cases it will most likely be used for asylum construction; but perhaps the majority of our asylums are built of brick. We have outlived the time when "Capability" Brown said that "a red brick "house puts the whole valley in a fever"; and when Repton called a brick house "a scarlet sin against good taste." Our views have changed for the better since 1773, when Brown died, and we now think that a well-designed brick house improves a landscape, especially if it be made of the beautiful plum-coloured bricks common in Queen Anne's time; but not so easily obtainable now. Whether brick or stone be employed the quality should be of the best. Porosity, or a tendency to scale or crumble should be guarded against, or the wall will prove damp. In some counties it is the custom to have the outer walls made with an air space of two or three inches. This not only prevents the damp from penetrating, but it has a tendency to equalise the temperature of the ward. Perforated bricks make a wall which is at once strong, light, and dry.

The inner walls should be plastered throughout, or, preferably, covered with Portland or parian cement. It is not on æsthetic grounds only that I insist on this, but for sanitary reasons also. The joints of brickwork can never be made perfectly smooth. Dust collects in the grooves and irregularities, and dust too often means disease. A skirting-board implies that there is a space at its back for collecting dust and dirt, and for affording a pleasant playground for rats and mice. It should be abolished, and a strip of wood about two inches wide and one inch thick nailed to the floor close to the wall.

The space between the foundation walls should be filled in, and a thick layer of concrete should rise to within an inch-and-a-half of the floor level. On this concrete wood blocks should be laid, a thick layer of Stockholm tar being placed next the concrete. By these means neither damp, sewer gas, nor vermin can get under the floor. It is also both warm and the tread noiseless—important points in asylums and hospitals.

The favourite kind of window at present is the ordinary double hung sash window. Why it should be the favourite is not easy to see.

In asylums it has to be blocked both top and bottom, merely allowing an opening of about four or five inches. The consequence is that the amount of air admitted is insufficient in warm weather. Further, it is most difficult to keep clean. Dirt accumulates between the sash and the frame, and the cords are constantly breaking. A

modification of the French casement is much to be preferred. The upper part should be an oblong swivel, or hinged fanlight, and the lower divided at its centre by a strong mullion; the sections being fitted with sashes moving on central pivots. An asylum needs abundance of light, and the windows should be more numerous, perhaps, than in any other building. Unfortunately, the amount of glass necessary for light is apt to make the wards somewhat cold in winter. It would be very desirable to have all the windows double, and in this case the inner window might be on the double-hung sash principle. No blocks would be necessary, and ventilation, without draught, would be easily maintained. Wherever practicable the windows should be placed opposite to each other, and the width of the room should rarely exceed 25 feet, or perflation is likely to be imperfect. The upper panels of the doors should be, almost without exception, of strong plate-glass, and the lower panels of open ironwork, fitted in some cases with light wooden shutters.

The staircases are almost invariably of stone. In most asylums they are too narrow, and the risers too high.

In designing any building the first principle is, that it be perfectly adapted for the purpose in view, and no flight of genius on the part of the constructor can justify his swerving for a moment from that principle. If the edifice can be made beautiful, so much the better; but beauty must be made subservient to utility and to hygiene. It is often justifiable to decorate construction, but hardly ever to construct decoration. What then is the best design for an asylum for the insane? The old conglomerate style is gone for ever, and the linear is fast following it. Nevertheless, there is something to be said in favour of the latter, especially if the word "linear" be not too literally interpreted, and the less important wards placed in *échelon*. It is, however, not very suitable for asylums exceeding 300 beds. Nowadays the block system in one of its many forms is that which is almost invariably followed in the construction of asylums of 500 beds and upwards. There are five chief ways in which the blocks may be arranged.

1st. The blocks are placed on either side of a straight corridor of communication. This does not look well in elevation, and it covers much ground, but it is a simple form of construction, and might be found really good from an hygienic point of view, because the circulation of air would be free, and the drainage easily arranged.

2nd. There is the broad arrow form. Here the straight corridor is, if I may venture to say so, bent at its centre and the blocks arranged in *échelon*. I am inclined to think that this plan is better adapted for an hospital than for an asylum. The difficulty of supervision must be great, at least in large asylums.

3rd. We have the corridors arranged in the form of the letter H, the blocks being attached to the free sides of the letter. In my opinion this is an objectionable form.

4th. The blocks are arranged in quadrangles, or rather parallelograms; the important blocks facing due south, and the other blocks having their ends south and their sides east or west; the administration portion of the asylum only being to the north. Several asylums have lately been built on this principle, and for compactness and facility of supervision it is unrivalled.

5th. We have the horseshoe form of corridor with the blocks placed all round the outer edge. It is probable that this principle will ultimately be developed into the best plan of all.

A detached hospital for infectious disease should form part of every asylum.

The height of a building will profoundly affect its hygienic qualities, because the higher it is made the greater will be the interference with the circulation of air around the ground floors; the greater will be the difficulty in lighting and ventilating the corridors of communication, and in securing perfect sanitary arrangements throughout. I have, therefore, no hesitation in stating that an asylum should never exceed two stories in height, and if any part of an asylum be three stories in height, the whole building may be described as faulty or unsuitable. Apart from the sanitary aspect of the question there are reasons why no part of the building should be three stories, but these objections are scarcely relevant here. I should, however, like to go further and affirm my conviction that a one-story building would be by far the best, whether viewed from a point of management as regards the staff; of comfort as regards the patients, or of ease in carrying out the principles of modern hygiene. Of course the objection would be at once raised that the amount of land covered by the building would be enormous. My answer to that would be that a one-story building for 500 or 800 patients would not need more ground space than one of two stories for 1,000 or 1,600 patients, and many of our public asylums exceed even the latter number. If I say that no asylum should exceed 800 beds I do not think I shall find my assertion contradicted by anyone conversant with the inner working of such institutions.

Whatever form of construction be adopted the blocks will be so arranged as to lie around, or on either side of the administrative department, which thus forms the centre, and contains the various offices, including a large recreation hall.

The patients' blocks will be divided into day-rooms and dormitories. The former will vary in size, containing from 10 to 50, or, perhaps, 100 patients; the latter will range from three-bedded rooms to those in which 100 may be placed. The size is somewhat important, as it is always difficult, and sometimes impossible, to provide efficient cross-ventilation in small dormitories. Probably those containing between 20 and 30 beds will be found the best. As I have already said, about one-fourth of the dormitory space should be in single-bedded rooms.

As regards the cubic space allowed per patient in a county asylum, it is in all 1,080 cubic feet, 600 being allotted to dormitory and 480 to day-rooms. The superficial space is 50 feet for the former and 40 for the latter. It follows, therefore, that the rooms are usually 12 feet high. This total of 1,080 cubic feet is by no means excessive; but it may be sufficient, provided the air is very frequently renewed. As each individual renders impure between 2,000 and 3,000 feet of air every hour, it follows that the air in asylum dormitories must be renewed from four to five times every hour, and this renewal of air is one of the most difficult problems with which the medical superintendent has to deal. In summer it can be managed, provided the external air is not perfectly still,—a condition which does not often continue many hours at a time in England,—but in winter, when the air is cold, and when the low nerve force of the lunatic has to be considered, the question bristles with difficulties, and I doubt whether any very satisfactory solution of the problem has yet been found. Abundance of open fires would meet the difficulty, but apart from the expense of such a system, it could not be carried out safely in dormitories occupied by the insane. Hot air may be supplied by one of the various slow-combustion stoves, by hot water or steam pipes, or by driving hot air into the rooms by means of fans. All these methods, however, provide warm air, and the patient is thus compelled to warm his body with the air he breathes —a proceeding wholly opposed to both the teachings of nature and to the principles of hygiene. I have elsewhere admitted that this artificial way of warming dormitories and day-rooms is often the least of two evils; but it must not be pushed; must be carefully watched, or a high death-rate from consumption may be expected. The fan system possesses one advantage over the others, namely, that in warm weather pure, cold air may be driven in, and thus other means of ventilation may be supplemented. There is, however, nothing special in the ventilation of an asylum.

The same may be said concerning the disposal of sewage, and the arrangement of baths and closets. The latter are usually placed in small blocks in rear of their respective wards. Care should be taken that the connecting passage between the wards and the closets is short —not exceeding a few feet—because if it be long there is some danger of it acting as an extraction flue, and by drawing the foul air into the ward increasing the very danger it is intended to prevent. A stove placed in the closet block would obviate this risk. A well equipped Turkish bath should never be omitted.

The main flue from the furnaces should be carried underground for some distance from the building, and the chimney should rise high enough to carry the smoke well clear of the grounds. It is a good plan to make use of the chimney as a sewer ventilator, and for this purpose a 12-inch pipe should be taken from the highest point of the main drain to the base of the chimney.

Much of the health of the patients will depend on an abundant supply of pure water. It should not be less than 30 gallons daily for each patient.

The electric light has not as yet made much way in asylums. Its gradual introduction is certain, and with the abandonment of gas another element of danger will be banished from the lives of the insane.

It will be gathered from what I have said that the hygiene of an asylum closely resembles that of any other large building. It is somewhat more difficult to carry out; but the special points are few, and need little emphasis to impress themselves on the minds of those conversant with the principles of general hygiene.

Construction and Arrangement of Asylums.

BY

G. T. Hine, F.R.I.B.A.

Asylum construction differs from other branches of architecture in its relation to hygiene in that it demands a consideration of the mental as well as of the physical welfare of the people, and no architect can hope to attain much success in asylum construction, who does not devote some study to the nature of the malady and habits of the unfortunate class for whom he provides accommodation.

The old days of prison-like cells, iron fetters, and strait waistcoats have happily passed away, but still there is much to be done by way of improvement; and an architect may assist materially in lessening the troubles and contributing to the cure of these poor people by the care and consideration he gives in providing them with bright and healthful homes, from which the idea of detention is as far as possible removed.

Unfortunately he has too often to contend with the objection that asylums are provided out of the county rate, and that his duty to the ratepayer demands that cost should be a first consideration. Unlike the hospital, where only physical disorders are treated, and a simpler form of construction is required, the lunatic asylum has not the pecuniary support, and therefore, to a less extent, the sympathy of the public; and too frequently an architect's first instruction is, that the cost per bed must not exceed a figure which is more applicable to the workhouse than to the hospital.

But in these days of progress, it is coming to be understood that we can do better service to the ratepayer by giving first consideration to other points than that of mere cost, and that in providing buildings skilfully designed and well constructed, we afford the best opportunities for successful treatment and speedy cure, and thus are studying the truest economy.

In the short time allowed me for this paper I must restrict the interpretation of my theme to its narrowest limits, and regard the

asylum as meaning only the pauper institution, and not the hospital for private patients. The first principles, however, of arrangement and construction are more or less observable in all forms of homes for the insane, and if we allow a somewhat more luxurious development in the private asylum, we might fairly apply the following observations all round.

Before touching upon the construction of asylums I ought to say a few words on the selection of a site, though unfortunately it rarely comes within an architect's province to advise about this; generally the site is purchased before the architect is called in to design, or compete for the erection of the building.

A word in passing about competitions, which are unfortunately gaining ground—I say unfortunately, because they are not always calculated to produce the best results. Too much importance is attached to the mere design, without regard to the details of construction, or the practical experience of the author; and it not unfrequently happens that a good workable plan has to be sacrificed to the symmetrical outline, necessary to make it attractive *on paper* and give the author a chance of success.

A site should, in my opinion, be, firstly, on high ground. I believe, in a mentally hygienic sense, much depends on elevation. It is a known fact that in some parts of the world the intellectual standard is lower in the lowlands than in adjacent higher districts; and I should much like to see some statistics of cures effected in asylums on elevated situations, as compared with others on lower ground. Secondly, the soil should be dry, and sufficiently porous to allow of the sewage being used on the land; and thirdly, an abundant supply of good water should be available.

If the site is on a slope, it should be a southern one, or should allow of the rooms constantly occupied by patients facing the south or south-east. Sunshine is a necessity where the relief of mental depression is aimed at, and care should be exercised in reserving the best aspects for the patients' *day* rooms.

In the general arrangement of an asylum, the first question to be determined is the principle on which it should be built. In this country asylums are built either on the "pavilion" principle, where the different blocks are connected together, and communicate with the administrative centre by one-story corridors, or as continuous buildings; the latter being the most common and convenient plan for small asylums. Another form of asylum of recent adoption in America, and on the European continent, is that of entirely detached blocks, placed more or less distant from the central or main building, comprising a number of villas, in which patients can be very effectually segregated. It is claimed that the curative results are higher in this than in any other form of asylum; but I hope we may have a description of these buildings from some of our distinguished visitors, and I shall confine myself to the principles of construction known and adopted in this country.

When the principle is determined, the first care should be to arrange the wards in the best positions for aspect, light, and air, and all within easy reach of the administrative centre. In small asylums this is a comparatively easy matter, but in buildings accommodating from one to two thousand patients much consideration is required to succeed in all these respects. It is also important that the wards should be arranged so that the medical officers in their rounds may not have to retrace their steps unnecessarily.

The position of the wards is a matter of equal importance the day-rooms should all, if possible, have a southern aspect, certainly every ward should have one or more day-rooms to the south; and the blocks should not be built to look out on to one another. In large asylums this almost necessitates a plan on the "echelon" principle; and in *very* large buildings even this requires modification, or the length of the corridors would become quite impracticable.

On the classification of patients, and the positions of their various wards, much of the convenience of working depends.

In all asylums, unless built for special cases, there should be accommodation for the following:—

1. Sick and infirm, including a small ward for newly-admitted patients.
2. Acute or refractory cases.
3. Epileptics.
4. Quiet and working patients.

Some of these wards, again, admit of further sub-division, but the first and second should always be designed to allow of classification by providing two or three day-rooms in a ward, with one or more dormitories on the same floor, in addition to a proper proportion of single rooms.

The infirmary wards, which, including the reception ward, should generally provide accommodation for one-fourth the total number of patients, are best placed nearest to the administrative centre and to the medical officer's rooms, and should not exceed two storeys in height; or, if three, the top floor should be devoted to dormitories for quiet patients. Each ward should be self-contained on a floor, and should comprise one or more roomy dormitories, one with a southern aspect for bedridden patients, and with windows on at least two sides to allow of cross-ventilation, as indeed should be the case in *all* dormitories where practicable. The superficial area and cubical contents of these rooms should very much exceed those occupied by healthier patients (the Lunacy Commissioners say one-third more); at least two comfortable day-rooms should be provided for convalescents, one especially for dining in, as these patients rarely go to the general hall for this purpose.

The number of separate single rooms in an asylum is a point about which there is much diversity of opinion, and must to some extent be determined by the character of the patients. Generally, if the dormitories are numerous, and moderate in size, single rooms for one-fifth of the total number of patients will be considered sufficient, but

these must be judiciously distributed in something like the following order :—

Acute and refractory cases -	1	single room	to every	3 patients.
Epileptics - - -	1	„	„	5 or 6 „
Infirm - - -	1	„	„	6 or 7 „
Quiet and working - -	1	„	„	10 „

Single rooms should have shutters to the windows, and, except in the infirmaries, where one or two may conveniently be provided with open fireplaces for special cases, no single room should be warmed n this way. It is essential, however, that *every* apartment should be warmed and ventilated with proper inlet and extraction flues, of which more anon.

Doors *without* inspection holes or shutters are, in my opinion, best. In epileptic wards a narrow panel or other clear opening must be left to allow of an attendant hearing a patient when in a fit; but in other cases I think inspection holes or shutters suggest espionage, and are therefore undesirable, particularly as it is an easy matter to use a silent lock actuated by the handle, when the door can be opened as easily as a shutter, without disturbing the patient.

But to return to the infirmary. This should have, in addition to the single rooms last-named, rooms for attendants in proportion to the number of patients, excluding night attendants, who should be housed in a block by themselves in a quiet quarter; also lavatories, store rooms, and water-closet annexe, in common with all the other wards; and in addition to these, bath and dressing rooms. The other patients in asylums of any size will usually bathe in a general bath-house, but infirmary patients should have separate bath-rooms in their wards.

Each ward should also have a scullery, fitted with a small range, washing-up sink, and cupboards for crockery and utensils.

The water-closet annexe in the infirmary, as in all other blocks, should be constructed in a spur, separated from the building by a cross-ventilated passage. It should include closets, in the proportion of one to 10 or 12 patients, with an additional one for attendants, a small room for slop-sink and brushes, another for dirty linen, a coal place, and, on the male side, urinals. In addition to the general annexe, large dormitories in the infirmary wards should have a water-closet and slop sink attached, but separated by a cross-ventilated neck or passage.

While on the subject of closet annexes, I will refer to one or two special details of construction, as it will be impossible, in a short paper like this, to speak at length on all such matters. It is assumed that any architect entrusted with the erection of an asylum is well versed in all the leading questions of sanitary science.

The walls of all these offices should be faced internally with glazed bricks, or lined with enamelled tiles, which, though costly in construction, are easily washed and kept sweet and clean, and never require any outlay in paint. The floors should be of concrete, tiles, or some equally imperishable material not affected by wet. The doors of water-

closets should be low and raised a foot or more from the floor, to allow of observation, and should open outwards. The closet apparatus should be of simple construction, without valve or anything to get out of order. I prefer a hopper basin, straight down behind, with earthenware trap all in one piece, rather than a "wash-out" basin—a good quick acting cistern with large service pipe, but *not* with automatic action. Patients should at all times be encouraged in habits of cleanliness and order; and by automatic contrivances which relieve them of responsibility it seems to me you frustrate rather than encourage a healthy condition of mind. The objection of an occasional unflushed basin is a trifling matter, and one quickly remedied by the attendant. Urinals are best with only a back and an open channel, without wings or splash pieces; the less surface there is to wash the less chance of smell.

Next to the infirmaries should come either the ward for acute cases or for epileptics. In a small asylum the latter might be on the ground floor, with a ward for acute cases over; but, in any case, epileptics should, if possible, be housed both day and night on the ground floor. Their wards should be bright and roomy, the day-rooms rectangular, without breaks or obstructions, behind which a patient might get lost sight of while in a fit. There is not the same advantage in subdividing these rooms, as these patients are generally quiet, and, in their healthier moments, are more rational and appreciative of surrounding advantages than other classes of patients. The adjuncts to the ward should be the same as in the infirmaries, but with only one bath in connexion with the dormitory, for cases of emergency. The dormitory should be spacious, and large enough to hold fully five-sixths of the patients in the ward, the remainder sleeping in single rooms, which, unlike other wards, should open out of the dormitory; one or two only opening out of day-rooms for the use of troublesome or invalided patients during the day.

The ward for acute cases may be situated either on ground or first floor, if made sound proof, to prevent the disturbance of patients in rooms above or below. This ward is best broken up by dividing the day rooms into several smaller rooms by partitions partially glazed, so as to allow of the charge attendant controlling the entire ward. The single rooms, accommodating one-third of the whole number of patients, should open out of the day-rooms. There should be one or more associated dormitories on the same floor for troublesome cases; the remaining patients sleeping on the top floor of the building. In other respects this ward need not differ from the infirmaries already described.

The wards for quiet and working patients, or as they are generally somewhat erroneously termed, "chronic cases," may be very simple in design and arrangement. Were it possible to construct the entire asylum on this principle—as are those for imbeciles, built by the Metropolitan Asylums Board—that great desideratum, a cheap asylum, might be more readily obtained.

These wards may consist of large day-rooms, with associated dormitories of proportionate size, and a small number of single rooms. The dormitories may all be on the top or two upper floors.

A specially roomy boot-room, which I have omitted to mention as attached to all wards for outdoor boots, hats, and cloaks, should be situated near the outer entrance, with some lavatory basins for patients to wash in when coming from the workshops or off the land.

In addition to the foregoing, it is often convenient to have wards of simple arrangement in connexion with the workshops on the male side, and the laundry on the women's side.

Before leaving the wards, I should add, that, whether built on the block or continuous-buildings system, they should always be carefully designed with reference to the position of staircases, both for convenience of visiting and for affording means of escape in case of fire. No ward, particularly on the upper floors, should have less than two exits, at opposite ends, making it impossible for any patient to be cut off from escape.

Staircases should be of ample width, and easy of ascent, and always of non-combustible material, for which purpose concrete is better than stone.

It is scarcely necessary to say that floors constructed on a fire-proof principle offer many advantages both against the spread of fire and the conduction of sound, and do not add so much to the cost of a building as is generally supposed. The Lunacy Commissioners require that the ceiling next the roof of all rooms occupied by patients shall be of fire-proof construction, and therefore, in two-storey buildings only one more floor remains to be of similar construction to make the building entirely fire-proof.

Coal lifts are sometimes introduced in asylums, but, in my opinion, are better omitted, as being dangerous, and also as robbing patients of work which they can generally well do. Sometimes I provide an outside staircase to a coal place in the W.C. annexe, the inner and outer doors of which have different keys, thus allowing coal to be brought by men to the women's side without their being able to get into the ward. These staircases also constitute additional ways of escape in case of fire.

The administrative department should be centrally situated between the male and female blocks, and arranged to allow of easy aproach to the recreation hall, kitchen, stores, and laundry buildings from both sides, without the two sexes coming into contact. It should comprise—

1st. A large hall for recreation purposes, capable of seating fully half the number of patients in the asylum, in which a stage should be arranged in a recess at one end, with convenient approaches and dressing rooms.

In small asylums the hall is frequently placed on the ground floor, with the chapel over it, this being convenient for approaches, and also economical in construction.

2ndly. A good kitchen, with sculleries, larders, and pantries sufficient for all patients and officers in the asylum, and near to the recreation hall, if this be used as a dining room. In some asylums one or

two large patients' dining halls are provided in addition to the general hall, when this is used exclusively for recreation purposes. Mess rooms for attendants and nurses should be situated near the kitchen.

3rdly. A general or steward's store, which, like the other buildings, should be easily accessible from both sides, and also have a cart road approach for delivery of stores.

4thly. The laundry buildings, which, if not quite central, should be on the women's side, but with a direct approach from the men's wards, and should comprise wash-house and ironing rooms, foul wash-house, and, in large asylums, separate wash-house for officer's linen; also, drying stoves in each of the wash-houses.

An admirable system of drying, which I first introduced at Nottingham, and am now using in two other asylums, is obtained by blowing or drawing warmed air through the horses by a fan. The clothes are thus dried much quicker, and with a fresh and sweet result. I find at Nottingham that before all the horses are filled, the clothes are dry on the first horse, and thus a constant succession of changes can be made, and the clothes dried as quickly as they are washed.

5thly. The central buildings should also include, near the principal entrance, one or two good visiting rooms; also committee, waiting, and porters' rooms, a superintendent's office, and rooms for the assistant medical and other officers of the asylum.

The superintendent's house, which, in many asylums, is incorporated with the central block, should, in my opinion, be an entirely detached building, or, at the most, be connected with the asylum by a corridor of some length.

The responsibilities of a superintendent make it very desirable that he should at times be able to shut his mind to his work, and this he could do more effectually if his house were some little distance from the asylum. Moreover, if a married man, it is not fair to his family that they should be brought up in close association with the asylum and its influences; and I venture to think further, that a superintendent's work would generally be better done with his office in the asylum and his house some little distance away, and without any corresponding disadvantages, providing that a telephonic or other means of communication be arranged between his house and the asylum, and that one or more assistant officers sleep in the main building.

The position of the chapel is another vexed question. It should be designed in all respects to convey to patients the idea of church, and for this reason is better a detached building in the grounds. On the other hand, it is very undesirable in wet weather to have to take several hundred patients some distance to church. When possible it is best to erect it outside the main building, with a connecting corridor in addition to outside entrances, either of which may be used.

Separate blocks for nurses and attendants, containing sitting and club rooms, where they can associate when off duty, with bedrooms above for those who do not sleep in the wards, are very desirable adjuncts.

A dispensary is always required; and sometimes an operating room, with one or two sleeping rooms adjoining, is a great convenience, indeed, almost a necessity in a large asylum.

Workshops should also be provided on the men's side, with separate shops for different workers, the variety and size of these shops being governed by the number and class of patients; and, in country asylums, farm buildings in a convenient part of the estate.

An isolation hospital, a short distance from the main building, should be constructed for infectious cases; this should comprise an associated dormitory with one or more single rooms on each side, a kitchen, laundry with disinfecting stove, and other necessary adjuncts.

Mortuaries for both sexes, with *post mortem* room, should be in a separate block, away from the main building.

I have, I fear, already exhausted more than my allotted time, and I dare not trespass further on your patience by saying anything on details of construction or internal fittings, though very much of the success and comfort of an asylum depends on the consideration given to these details. Nor have I time to touch upon the subjects of drainage and disposal of sewage, water supply and service, lighting, by gas or electricity, all of which are matters of much interest, and with which the asylum architect must be well conversant. One further subject which I must refer to, is that of heating and ventilation, which is so all important a matter in asylum construction that my paper would be incomplete without it.

In my opinion any system for warming and ventilating should fulfil the following conditions:—

1st. It should offer the least risk of injury to patients by accident or danger to the building by fire.

2nd. It should be under the perfect control of the engineer, who should be able to raise or lower the temperature in any ward readily.

3rd. One system should combine the double duty of warming and ventilation.

4th. Ventilation should not be dependent on natural atmospheric action, which cannot always be relied upon to create a circulation of air.

5th, and lastly. It should be reasonably economical in working.

After long consideration, and some years of experience, I have come to the conclusion that the right system is one of air warmed over hot water or steam pipes, and propelled into the wards by a fan, through underground trunks, and vertical flues in the walls communicating with all the rooms, and a similar system of extraction flues, by which the vitiated air is expelled.

It must be understood that I do not advocate air warmed by fire heat, a method which may seriously deteriorate its quality, a result not to be feared by warming over steam batteries, which plan has the further advantage of allowing the temperature to be quickly raised or lowered in any particular ward by a simple arrangement of pipes and valves.

I cannot attempt to describe my system in detail, but will merely call attention to a few important points.

The air which is propelled into the building must be drawn from a situation untainted by obnoxious surroundings.

The trunks and flues must be carefully calculated in proportion to the size of each room. Many failures in ventilation are due to ignorance or neglect of this.

Separate trunks for day and night service should be arranged, with simple shutter valves for closing the one and opening the other at morning and night.

The extraction flues should communicate with upcast shafts of some height, say in towers, to carry well away the vitiated air.

The fresh warmed air should enter the rooms near the top, and the vitiated air be withdrawn near the floor; experience having taught us that this is right; for, if the positions of inlets and outlets were reversed, some deleterious gases would not readily ascend to escape at the top, while the warm air, entering at the bottom, would quickly ascend and pass out without mixing thoroughly with the surrounding atmosphere, as it must do if driven in at the top, and be allowed to spread over the whole surface of room, gradually falling as more air is forced in above it, and vitiated air extracted below.

When ventilation is required without heat, the fan may be used to drive in air at its normal temperature, the stagnant atmosphere in the rooms being of necessity displaced either through the extraction flues or the open windows.

One great advantage of this system is, that heat can only be obtained in conjunction with ventilation, which is not always the case with steam or hot water pipes *in* the wards, where a close stuffy heat is generally the result.

I cannot better illustrate the results of this system than by quoting from a recent report of the Superintendent of the Nottingham Borough Asylum, where I have lately introduced it in the new male annexe.

"So efficiently has the heating been done that a temperature of "60 degrees has been easily maintained throughout the wards without "the aid of any fires, and this when the thermometer outside registered "10° of frost. The dormitories and single rooms are just as easily "warmed at night.

"Those who are acquainted with the working of an asylum will "readily imagine the immense comfort of being able to do without fires "in the wards. There is no crowding round the fireplaces, and no "quarrelling for the best seats, but the patients sit scattered about at the "windows and at the tables, just as in summer. It was expected that "there would be some grumbling at first at the absence of fires, but, "strange to say, I don't think I heard a single complaint. Another "great advantage this system of heating has over most others is, the "entire absence from the rooms of all pipes and other heating surfaces.

"The ventilation is also equally successful. It is very observable "in the dormitories and single rooms; the air in these appears to be "almost as pure in the morning when the patients get up as in the "evening when they go to bed."

In conclusion, I must express my regret at the time I have been compelled to take in order to describe, but briefly, the arrangement of an asylum. There are very many interesting points of detail and construction I should like to have referred to had it been possible. I hope, however, my shortcomings will be remedied by others present in the discussion which is to follow.

DISCUSSION.

Dr. Saunders (Medical Superintendent of the Sussex County Asylum, Hayward's Heath,) said that in the arrangements of asylums there was nothing more important than the water-supply. If the site was not good the water would often get polluted. The selection of a site was, therefore, also a most important matter.

Mr. Banister Fletcher (Professor of Architecture and Building Construction, King's College,) pointed out what seemed a little like a contradictory statement in Dr. Greene's paper. In one part of it, double-sash windows were condemned, while a little further on an opinion was recorded in favour of the double-hung sash principle. He wished to ask Dr. Greene whether the 12-in. pipe for air referred to in the paper was to be connected with the base of the chimney.

Mr. Rogers Field, M.I.C.E., said that mere design in the arrangements of an asylum was in the province of the architect rather than in that of the engineer; but the water-closets and the sanitary arrangements generally were matters for the engineer. The first question was, how were they going to treat the inmates of an asylum? Should they be treated as responsible persons, or were they to be treated as not rational beings? Were they to use a pull in the water-closets, or an automatic apparatus acted upon by the door or the seat? Were they to mistrust the patients, or were they to employ apparatus to be worked by the patients themselves? He agreed with Dr. Saunders in thinking that to treat the insane as irrational beings was not the right way. Two types of apparatus had been tried. Where the ordinary pull was employed, it had at first to be worked by the attendants, but after a time the patients learnt to work it perfectly. Everything he had seen in the last 10 years confirmed him in the opinion he had long ago formed, that patients in asylums might be trusted to use the ordinary apparatus. If the flush was automatic, working through the movement of the door or the seat, the apparatus was always getting out of order. He had been appointed to report upon the sanitary arrangements at a well-known asylum. In the examination he had made he found that three-fourths of the automatic flushing apparatus were not acting.

Mr. W. M. Mackison (City Engineer, Dundee,) preferred that the windows in asylums should have, not a southern, but a western exposure. As the prevailing winds were those blowing between east and west, the western aspect was the most salutary. He agreed with the author of the paper with regard to the tiling of walls. With respect to the ventilation of buildings, he had no faith in apparatus for extracting air, because they caused a draught, and a draught was always bad. In a hospital with which he was connected they took pure air from a high tower and admitted it into the wards through an inlet placed about 6 ft. above the patient's bed, and also by an inlet placed below the level of the bed. Fires were of no *use except to give* a cheerful aspect to the wards.

Sir Robert Rawlinson said that with regard to the position and arrangements for water-closets in asylums, there was necessarily a great difference in different asylums. In some the patients could be trusted, but in others not. Some patients would get their hands down into the pan if they could. Such patients should be specially provided for. With regard to earth-closets, which the Government wanted to see introduced, generally there was again trouble with the class of what were called "the dirty" patients, who smeared everything within their reach. They had tried railing round the seat, with a 10-ft. fall below, so that such patients could not get at the excreta, but they found that more water was wasted in cleansing and keeping clean the apparatus than flushing apparatus would have required. Many years ago at Wakefield Gaol, where the prisoners were treated on the separate and silent system, there was a great outbreak of typhoid fever. The result of an examination by medical experts was an utter condemnation of the whole building, root and branch. After a brief examination, he found on each side of one end of a dividing wall a pan-closet, each closet being connected with the sewer by a 4-in. pipe, running straight down the wall into the sewer, which was never cleansed nor flushed. The criminals found out that by lowering the trap or pan and holding their heads down over the container they could converse through the closets with the prisoners on the other side, but while doing so they were breathing the sewer-gas, and hence the outbreak of typhoid fever. He examined the drains, and directed a 4-in. pipe to be continued up to the eaves to carry up the foul air. He found that the drains could be kept clean by flushing. The governor of the gaol invented a pan which, by means of a 4-in. lip, rendered it impossible for a prisoner to get his hand down or to remove the trap. These alterations, though simple and inexpensive, were effective, the infection disappeared, and the authorities were spared the great expense of a new prison. The flushing tank was, he felt bound to say, one of the greatest inventions of modern sanitary science, and it owed its progress more to Mr. Rogers Field than to any other sanitarian. The fame of the invention would long outlive the inventor. The benefit of a circulation of air could not be overestimated. At night his window was open (with Venetian blind down), and he thanked God that no window he ever knew of was air-tight. Windows with 6-in. beads at the bottom, so as to allow of being opened at the meeting-rail, were no danger even in winter. The air in rooms provided with them was always sweet.

Mr. H. H. Statham said he was glad to hear the remark with regard to the admission of air at the lower part of the room, and he rose to support it. In admitting air at the top they were opposing natural action, but in admitting it at the bottom natural action was helped. Fouled air always had a tendency to find its way to the top, and to bring the fresh air from the top was to bring it through the stratum of fouled air, some of which it would drag down with it.

Mr. Blair (Borough Surveyor of Bootle) said there were two well-known plans of ventilation, the first being that by which the air was extracted from the top; and the second that by which it was extracted from below. He had experience of two police-courts in which these plans had been respectively carried out. In the first case, where the air was extracted from the top, the result was good when the court was empty; in 12 minutes the air was entirely changed. But when the court was crowded the case was altered. The air very soon began to smell, even near the bench. In the other court, which was supplied with Tobin's tubes placed at the top, there was never a smell. The extraction of foul air from the floor was, in his opinion, the best plan.

Mr. Mackison (Dundee) added that he had been led to adopt a mixed system, combining the two principles. If he put in pure air, he was sure of obtaining an advantage, but if he extracted air, he might take out pure air with the impure.

Dr. Greene, in reply, said he agreed with Dr, Saunders as to the importance of a site which would afford the chance of a good water supply. In answer to Professor Banister Fletcher, he said double-sash windows were objectionable when blocks had to be used, but when the window itself was double there was no necessity to use blocks. The air-pipe referred to opened into the chimney at the base.

Mr. G. T. Hine, in replying, said two points which had been referred to ought to have a word in reply. When Mr. Mackison advocated wards with a western aspect rather than those facing the south, he probably had in mind a fever hospital. In building a hospital where the patients were always in bed, wind was a more necessary element than sun, but in lunatic asylums, sunshine was a necessity if a cure was to be effected. The patients would be up and about, and opportunities should be given for exercise at all hours of the day in the open air. In large buildings, such as the Claybury Asylum, they should be glad to get any outside aspect, east, south, or west, but if the principal front was to the south, they must have east or west as well. The other point had reference to the vexed question of how air ought to be admitted into a room. All depended upon the system adopted. If they trusted to nature, the proper point to extract from was the top of the room. He had studied the question for many years, and had made extensive experiments. When the question of inlet and outlet flues was first before him, he was as sceptical as a good many of those present. While building large board schools for 1,100 or 1,200 children, he had determined to try extraction from the top in one case, and extraction from the bottom in the other. He did not employ the Blackman fan, but something adapted to effect the same purpose. It was obvious that if mechanical power was employed to force air into a room, if the room were warmer than the surrounding atmosphere, the warm air would rise to the top of the room, and half of it might escape without mixing with the surrounding air, just as water might be forced through a lake, leaving the great mass of the water in the lake stagnant.

Sir Arthur Blomfield referred to a matter which had come before another Section, and which required to be dealt with at once. On the previous day a resolution had been proposed in the Section of State Hygiene which, in his opinion, more properly belonged to the Architectural Section. It was a question with regard to the education of architects. That section had passed a resolution in favour of the statutory examination and registration of architects. It appeared to him that such a resolution should have been at once referred to that Section.

Dr. Sykes then proposed the following *Resolution*, which was seconded by Mr. Ernest Turner, F.R.I.B.A., and supported by Mr. Rogers Field, C.E. :—

> "The members of the Architectural Section desire to consider the resolution adopted by the Section of State Hygiene approving of the statutory examination and registration of architects, before the definite adoption of the resolution by the Congress. They are of opinion that this question should have been referred to Section VI., 'Architecture in Relation to Hygiene.'"

The resolution was put, and carried unanimously.

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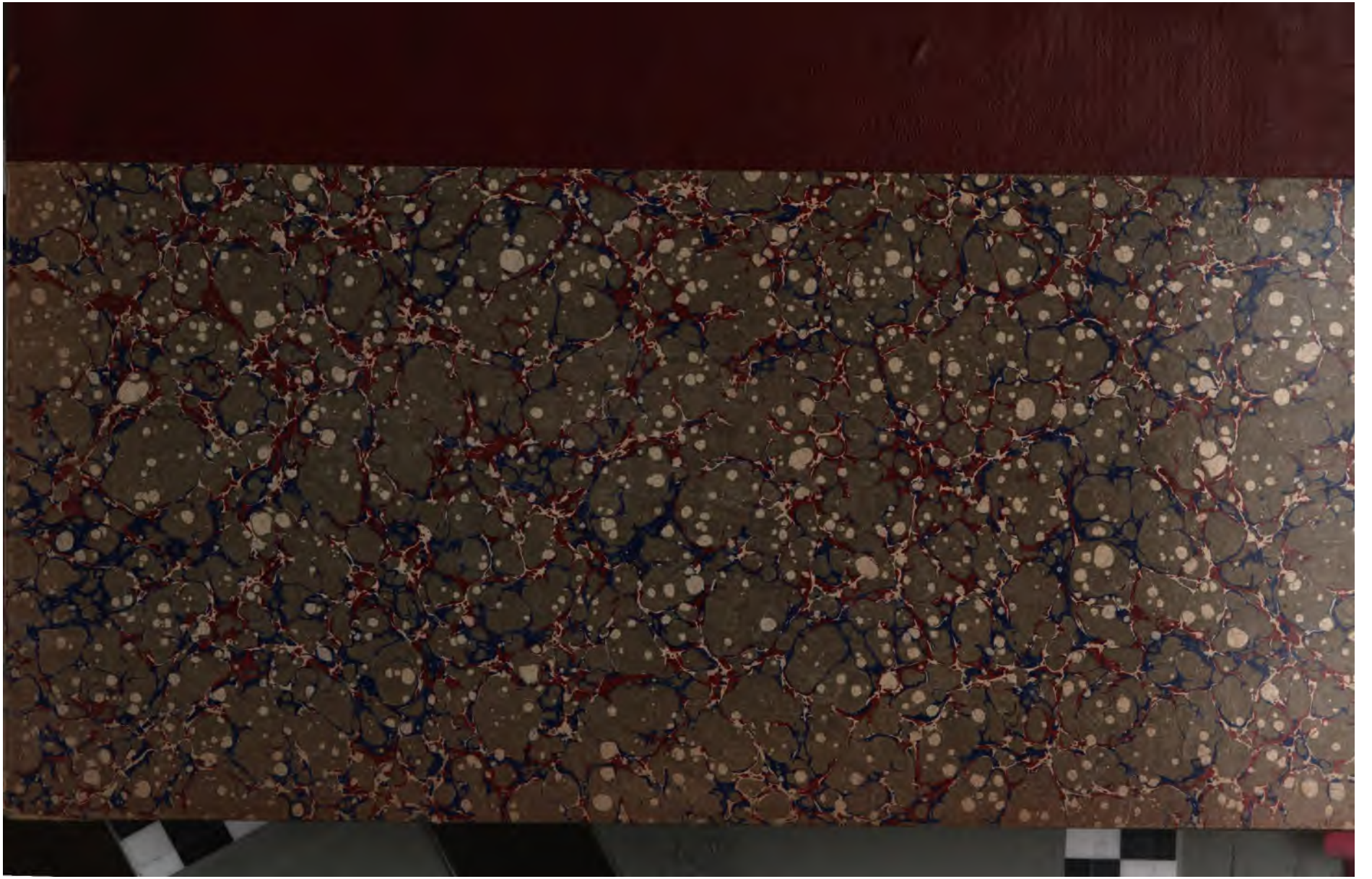
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